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The post-flood morphometry and bathymetry of Split and Stephens Lakes, 1989.

By Cherepak, B.C. 1990

Manitoba
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Manitoba Department of Natural Resources.
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ABSTRACT

Split and Stephens lakes, located on the lower Nelson River were flooded due to hydro-electric development in the region.

Bathymetric maps were produced and morphometric parameters were calculated in order to help evaluate the possible impacts of hydro-electric developments on these lakes.

At a lake surface elevation of 166.5 m ASL for Split Lake, the approximate post-flood area was 314.74 km^2. The mean water depth was 4.48 m and maximum depth was 23 m. Lake shoreline length totalled 417.86 km. The irregular shoreline of Split Lake was indicated by a shoreline development index of 6.65 excluding islands and 14.55 including islands. The volume of water contained by Split Lake equalled 1208.44 $m^3 \times 10^6$.

The approximate post-flood area of Stephens Lake was 421.33 km^2 at a lake surface elevation of 139.13 m ASL. The mean lake depth was 7.63 m and maximum depth was 35 m. The lake shoreline length totalled 461.28 km. An irregular shoreline development was indicated by an index of 6.34 excluding islands and 13.87 including islands. The volume of Stephens Lake was estimated at 2782.35 $m^3 \times 10^6$.

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INTRODUCTION

Split and Stephens lakes are located on the lower Nelson River northeast of Thompson, Manitoba (Fig. 1 and 2 respectively). These lakes were flooded as a result of hydro-electric development and the Churchill River Diversion. The average water level on Split Lake, located approximately seven kilometers downstream of the Kelsey Generating Station was raised in 1976 due to the increased flows resulting from the diversion of the Churchill River waters from Southern Indian Lake (South Bay). The completion of the Kettle Generating Station in 1970 resulted in the impoundment of the Nelson River creating the Stephens Lake reservoir.

Schlick (1968) described Split Lake before flooding as a relatively shallow lake with a mean depth of 7.01 meters and a maximum depth of 29.9 meters. Split Lake had an area of 283.9 square kilometers at a water elevation of 168.2 m (ASL). The confluence of the Odei and Burntwood rivers flow into Split Lake at the west end. The combined waters of the Nelson and Grass rivers drain into Split Lake in the south and the Aiken and Ripple rivers enter the southeast end of the lake. The Nelson River drains Split Lake to the northeast into an expansion of the Nelson River called Clarke Lake.

The water area of the Nelson River between Lower Gull Rapids and the dam at Kettle Rapids prior to flooding was estimated to be 101.5 square kilometers (Crowe, 1973). The water area has increased approximately 360% since 1970 with the inundation of an estimated 263 km^2 of land. The Nelson River enters Stephens Lake at Lower Gull Rapids in the southwest, and drains Stephens Lake through the

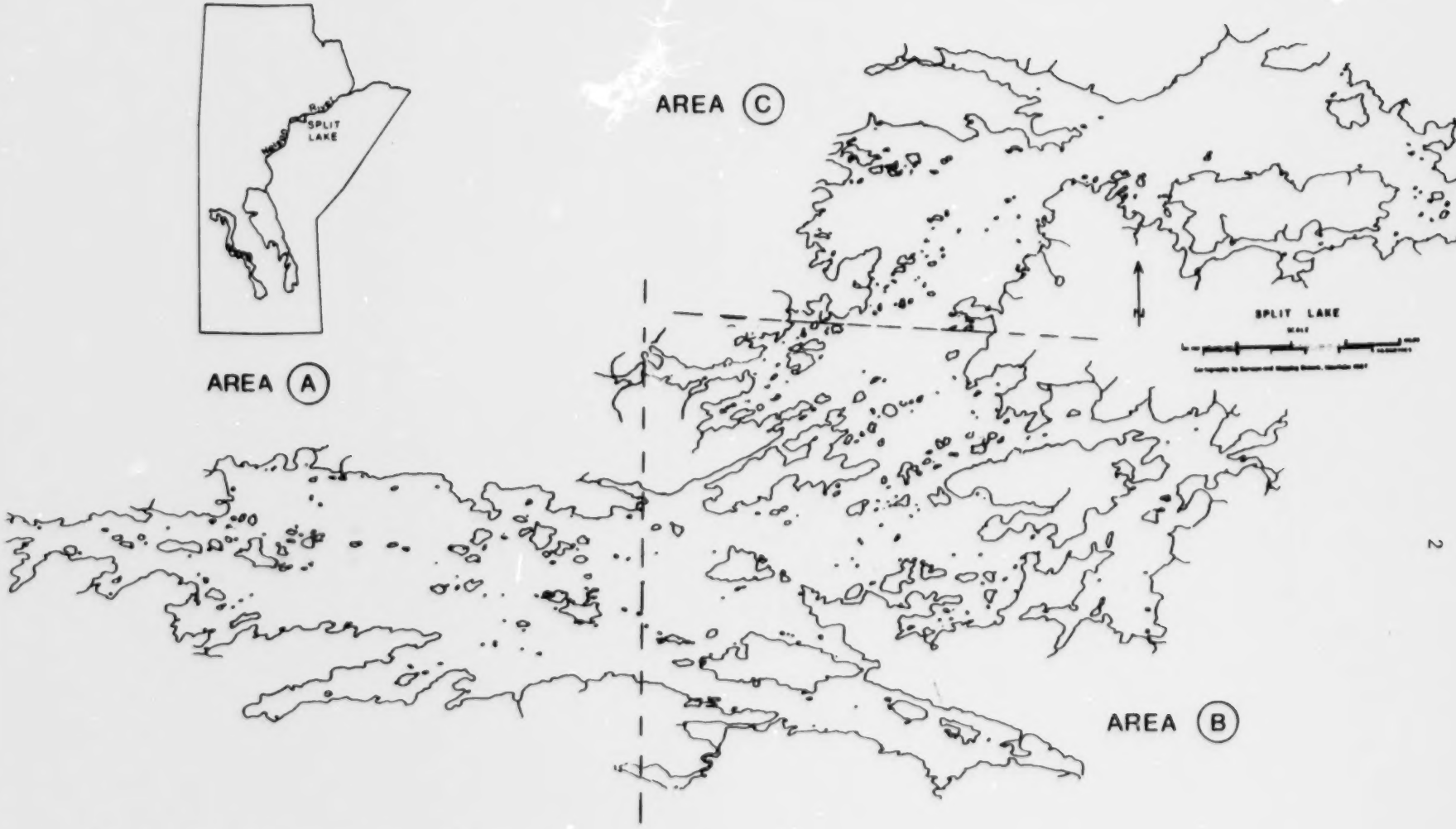

Fig. 1. Map showing the location of Split Lake in Manitoba and area sections of Split Lake, 1989.

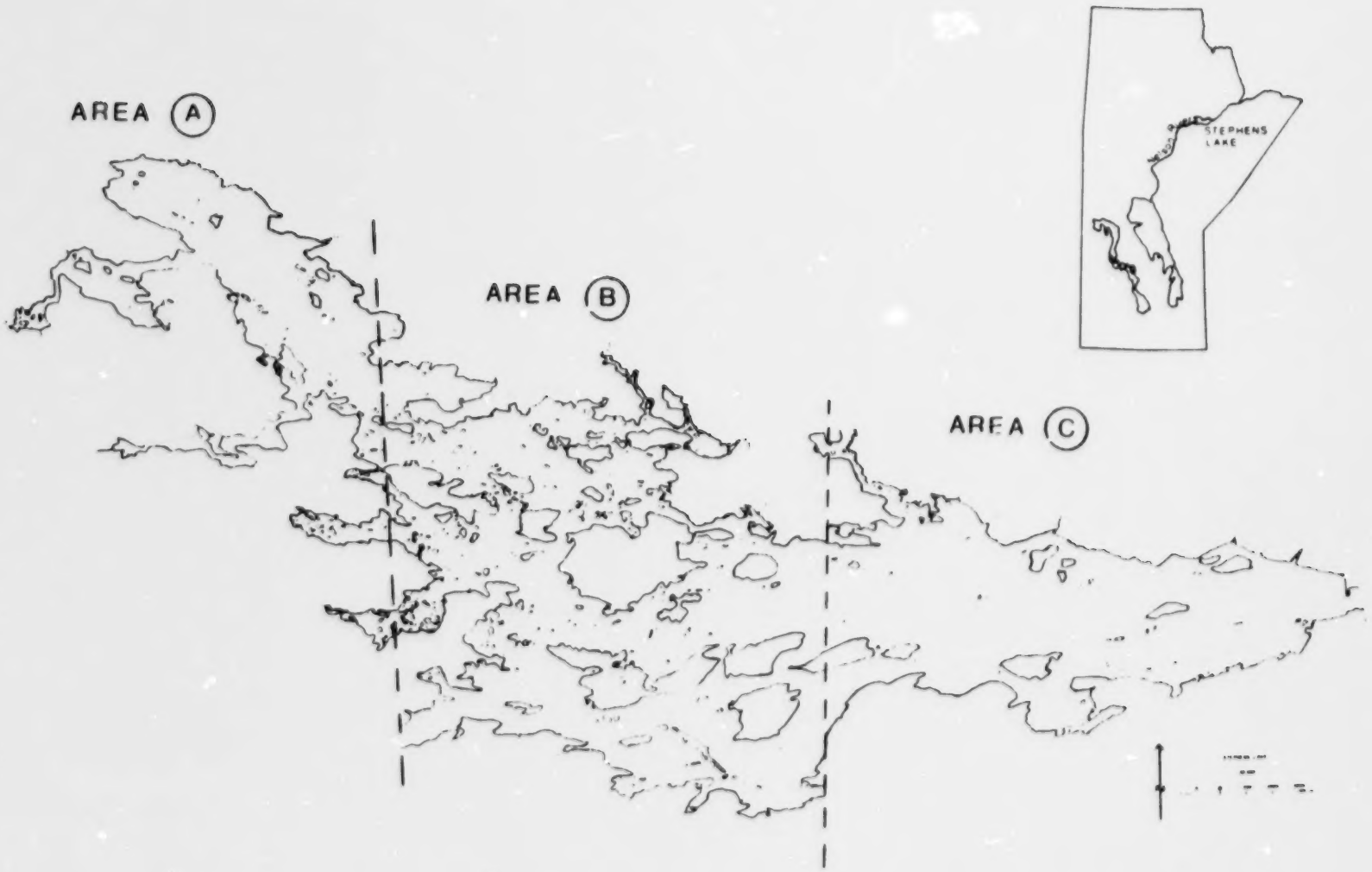

Fig. 2. Map showing the location of Stephens Lake in Manitoba and area sections of Stephens Lake, 1989.

Kettle Generating Station in the northeast. The North and South Moswakot rivers flow from the west into the Big Moose Lake basin at the northwest end of Stephens Lake. The Butneau River in the southeast no longer flows into Stephens Lake with the construction of the Butneau River Dam and Diversion.

The primary purpose of the report is to calculate the basic basin morphometric parameters (i.e. lake size, volume, depths, etc.) for the post-flood water levels of Split and Stephens lakes. The second objective is to produce bathymetric maps for both Split and Stephens lakes. The results will aid in determining the impacts on the various aquatic habitats affected by hydro-electric development and the flow diversion of the Churchill River.

METHODS

Contour Mapping

A bathymetric map for Split Lake supplied by Schlick (1968) is presented in Fig. 3. A hydro severence line map (Fig. 4), illustrates the original water bodies of Stephens Lake prior to flooding as well as presenting the new flooded shoreline. The post-flooded bathymetric map of Stephens Lake is shown in Fig. 12 (in envelope). A bathymetric map was produced for Split Lake; however, this report does not include a finalized map. For explanation see results section under Split Lake.

The bathymetric maps for Split and Stephens lakes were produced based on depth sounding results using Furuno FG200 MIC 3 and Furuno FE4200 depth sounders. Visual fixes on shoreline reference points were used to maintain transect direction. Transect locations for Split and Stephens lakes are shown in Fig. 5-10. The transects were done during August 24-25, 1989, for Split Lake and July 11-15, 1989 for Stephens Lake. Water levels at these times were 166.5 m ASL for Split Lake and 139.13 m ASL for Stephens Lake. The Stephens Lake elevation is a five day average for the depth sounding period. A five day average was use because of the large daily water level fluctuations during the sounding period.

The transects were transferred onto a 1:50,000 scale map for Split Lake and a 1:37,500 scale map for Stephens Lake. Water depths were then plotted along the appropriate transects using a Hughes Owens reciprocal protractor. Depth intervals of 3 m for Split Lake and 5 m for Stephens Lake were used for plotting the contour lines. Previous bathymetric maps as well as hydro severence line maps were used to aid

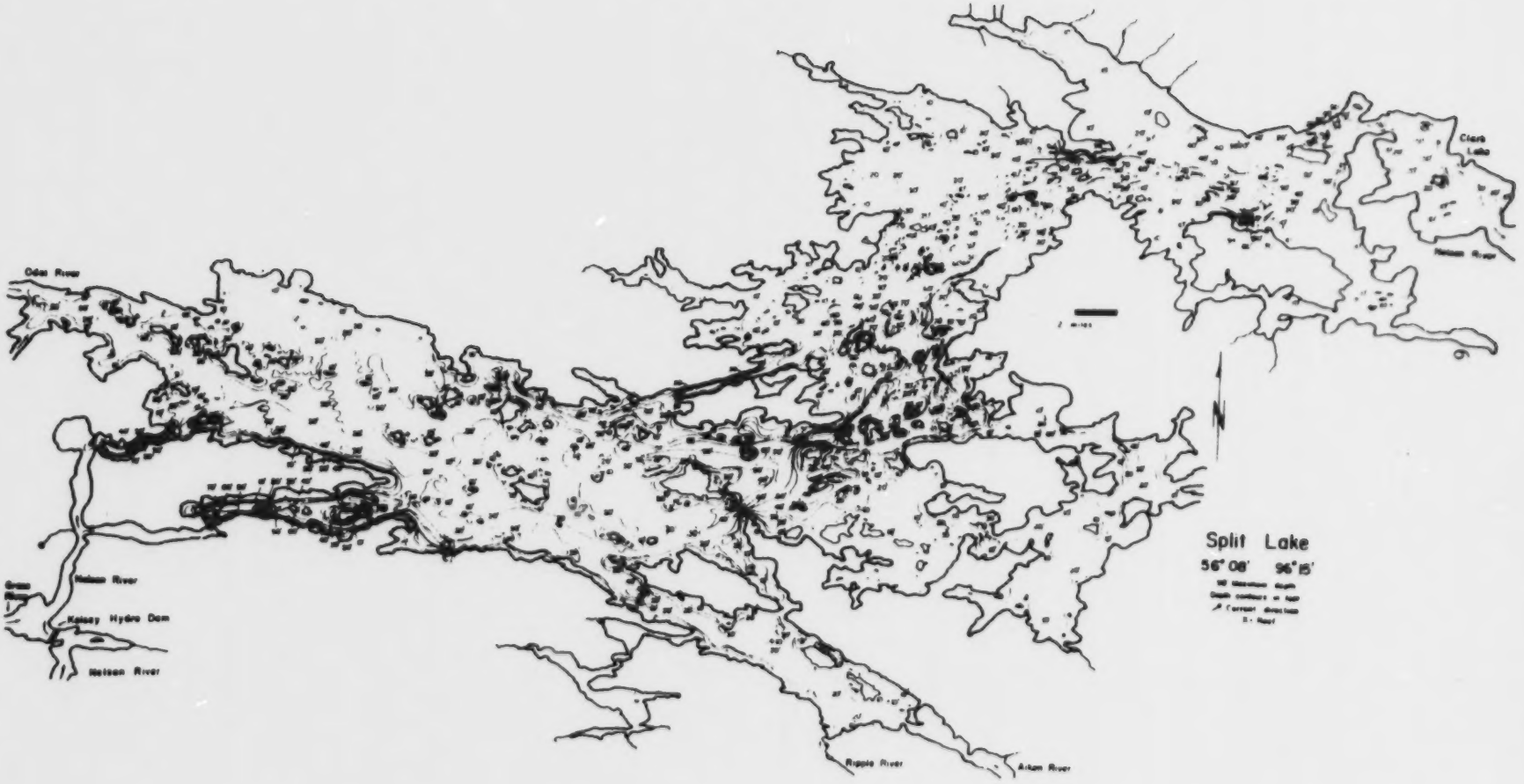

Fig. 3. Bathymetric map of Split Lake, (Schlick, 1968).

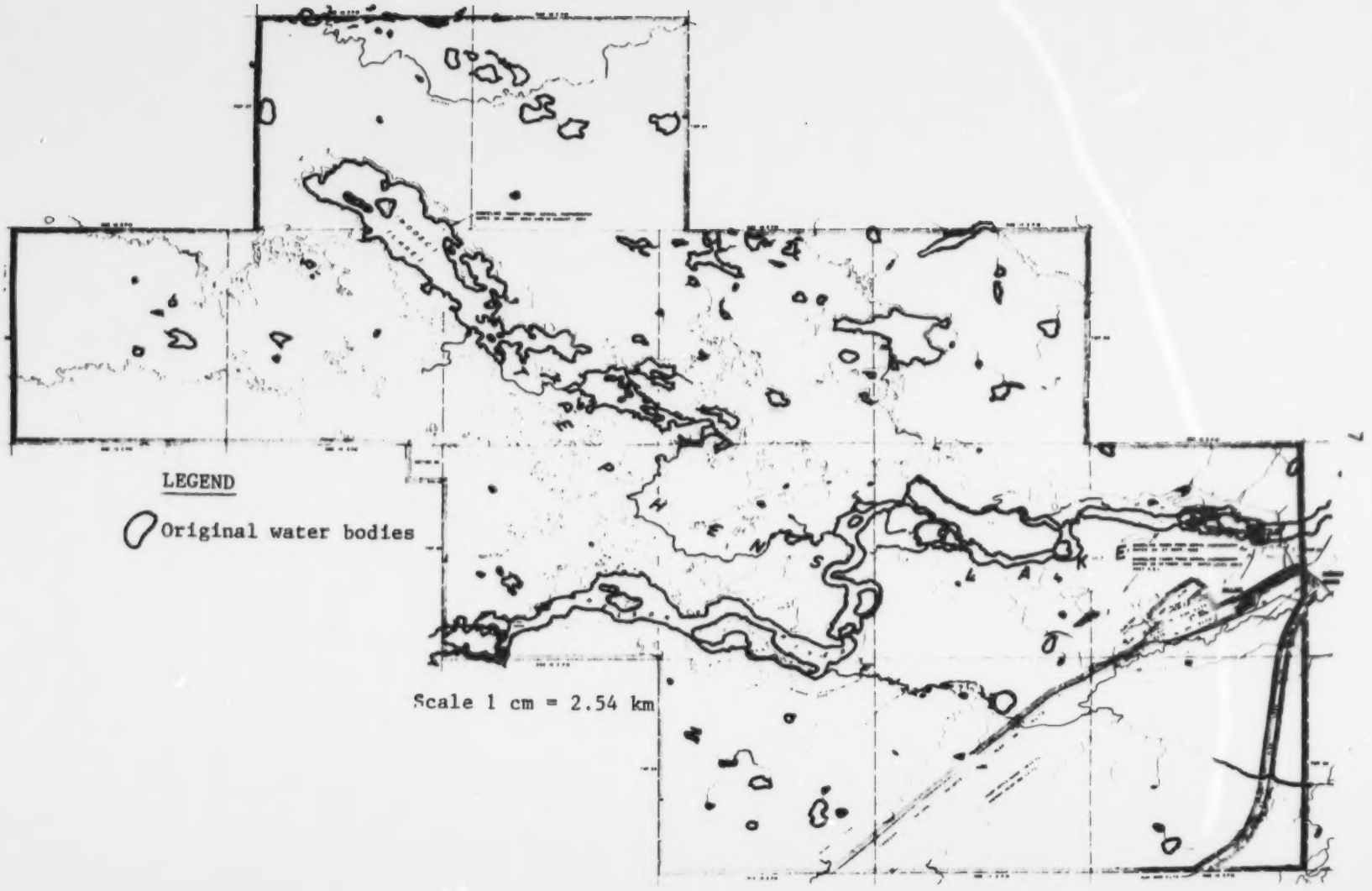

Fig. 4. Hydro severence line map showing pre-flood water bodies and post-flood shoreline of Stephens Lake.

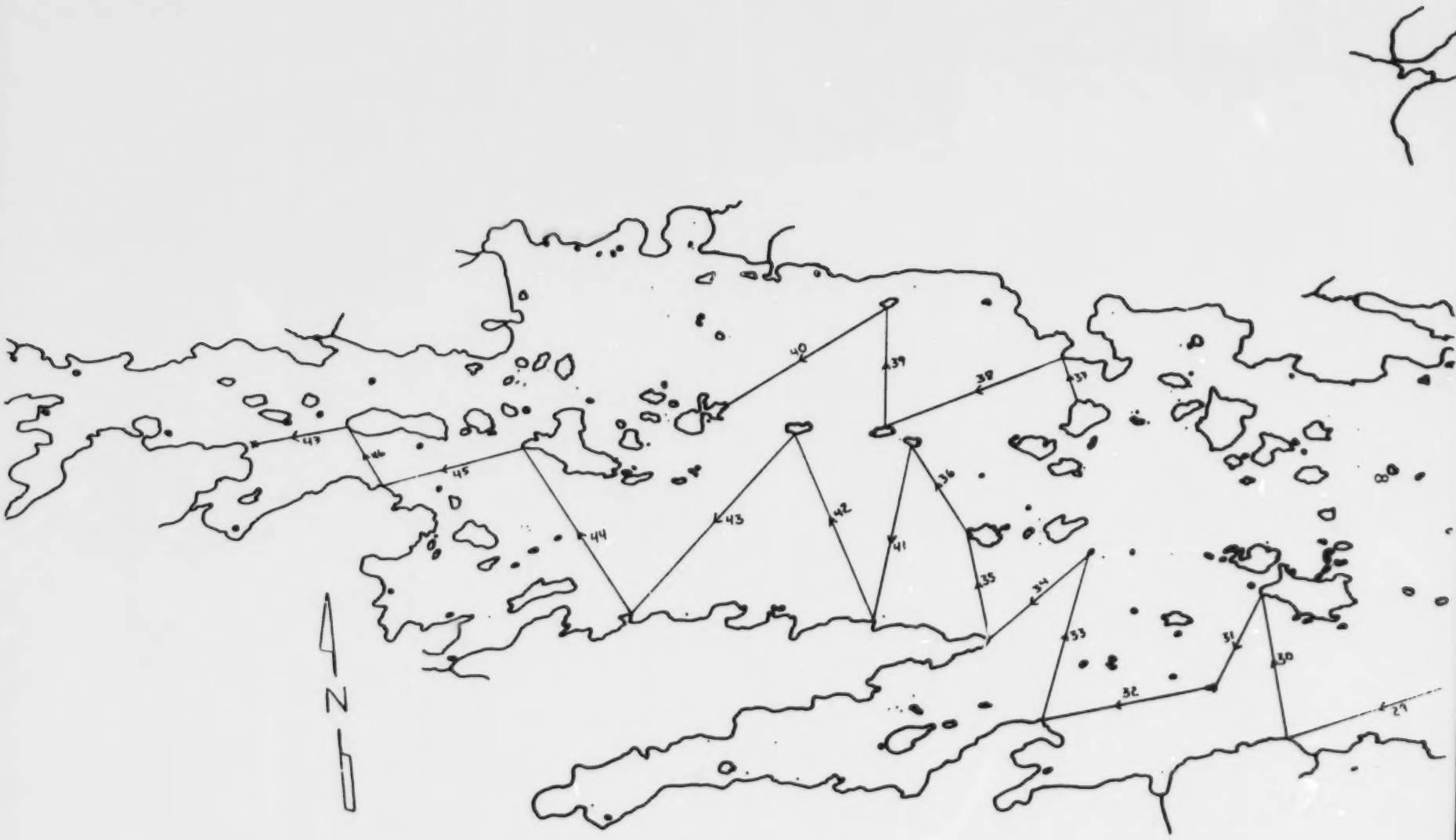

Fig. 5. Transect locations from area A of Split Lake, 1989.

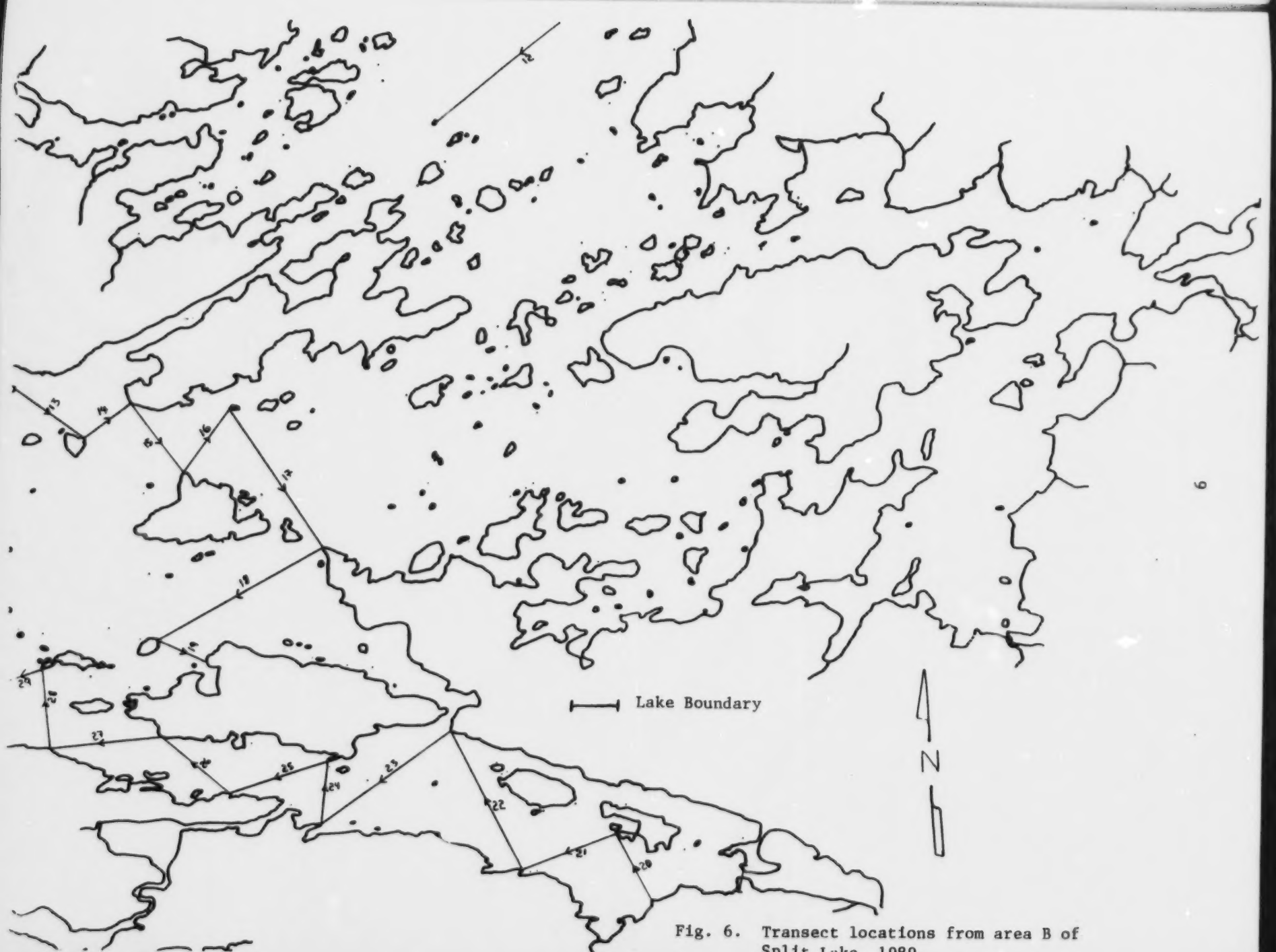

Fig. 6. Transect locations from area B of Split Lake, 1980.

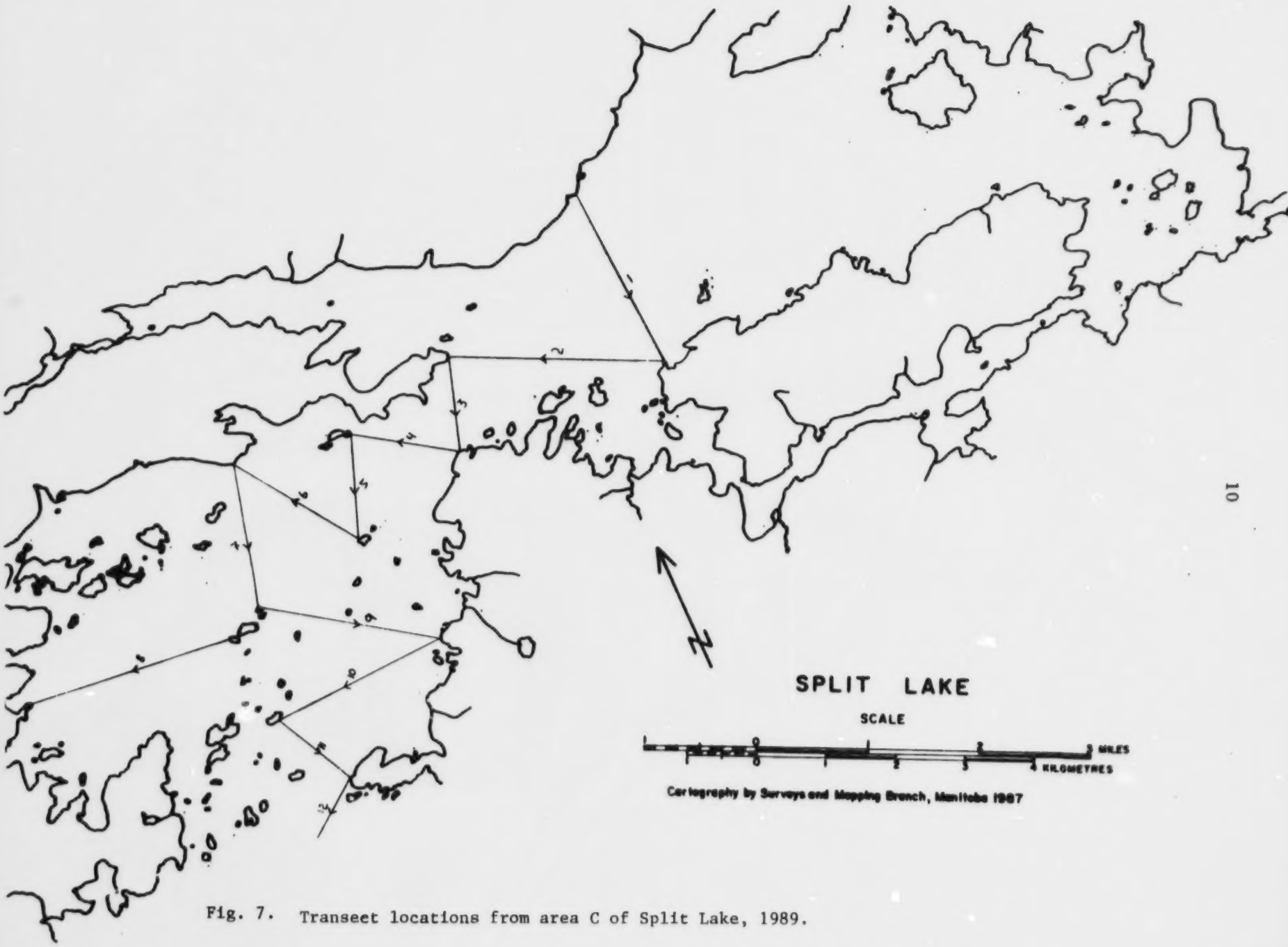

Fig. 7. Transeet locations from area C of Split Lake, 1989.

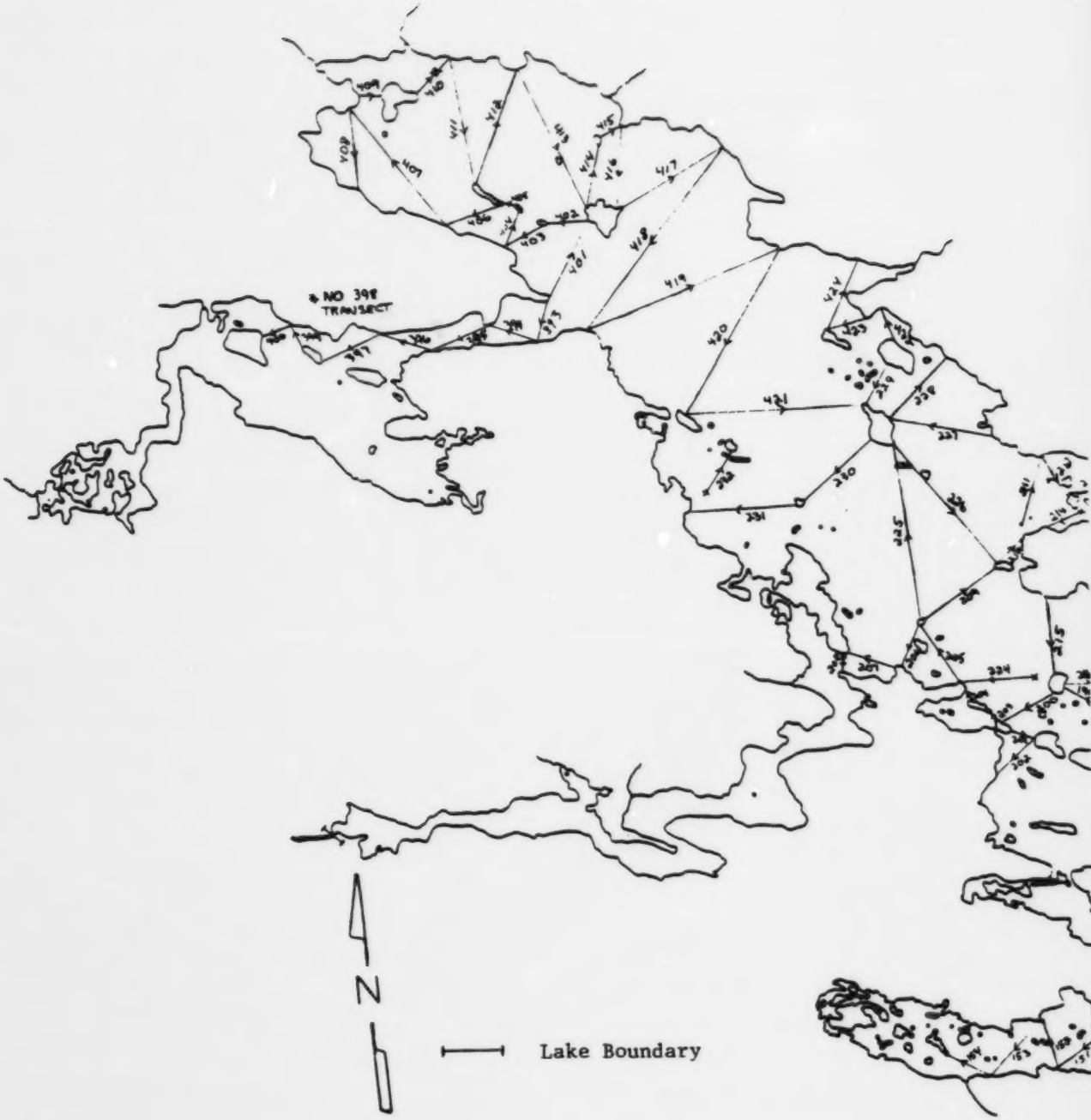

Fig. 8. Transect locations from area A of Stephens Lake, 1989.

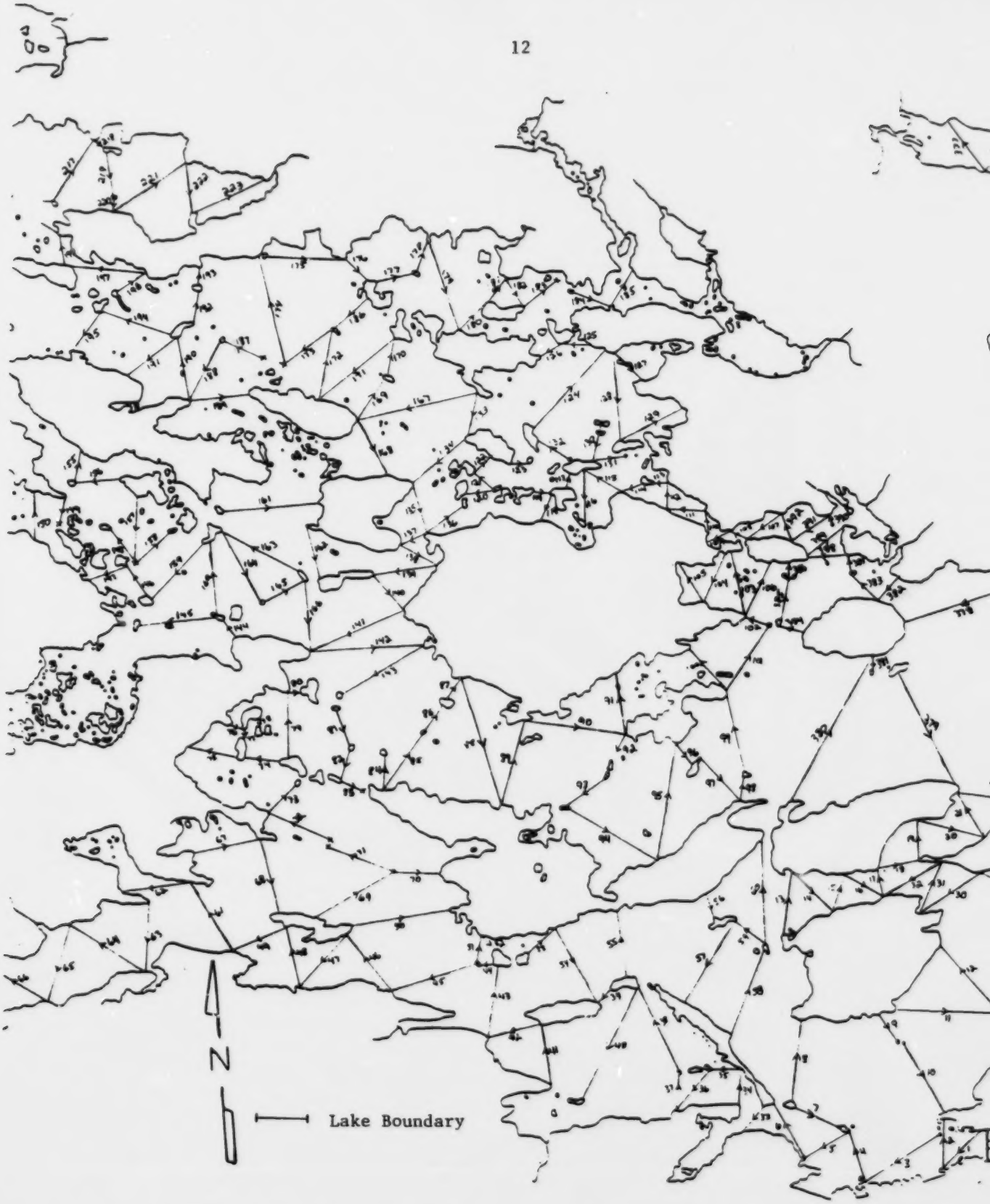

Fig. 9. Transect locations from area B of Stephens Lake, 1989.

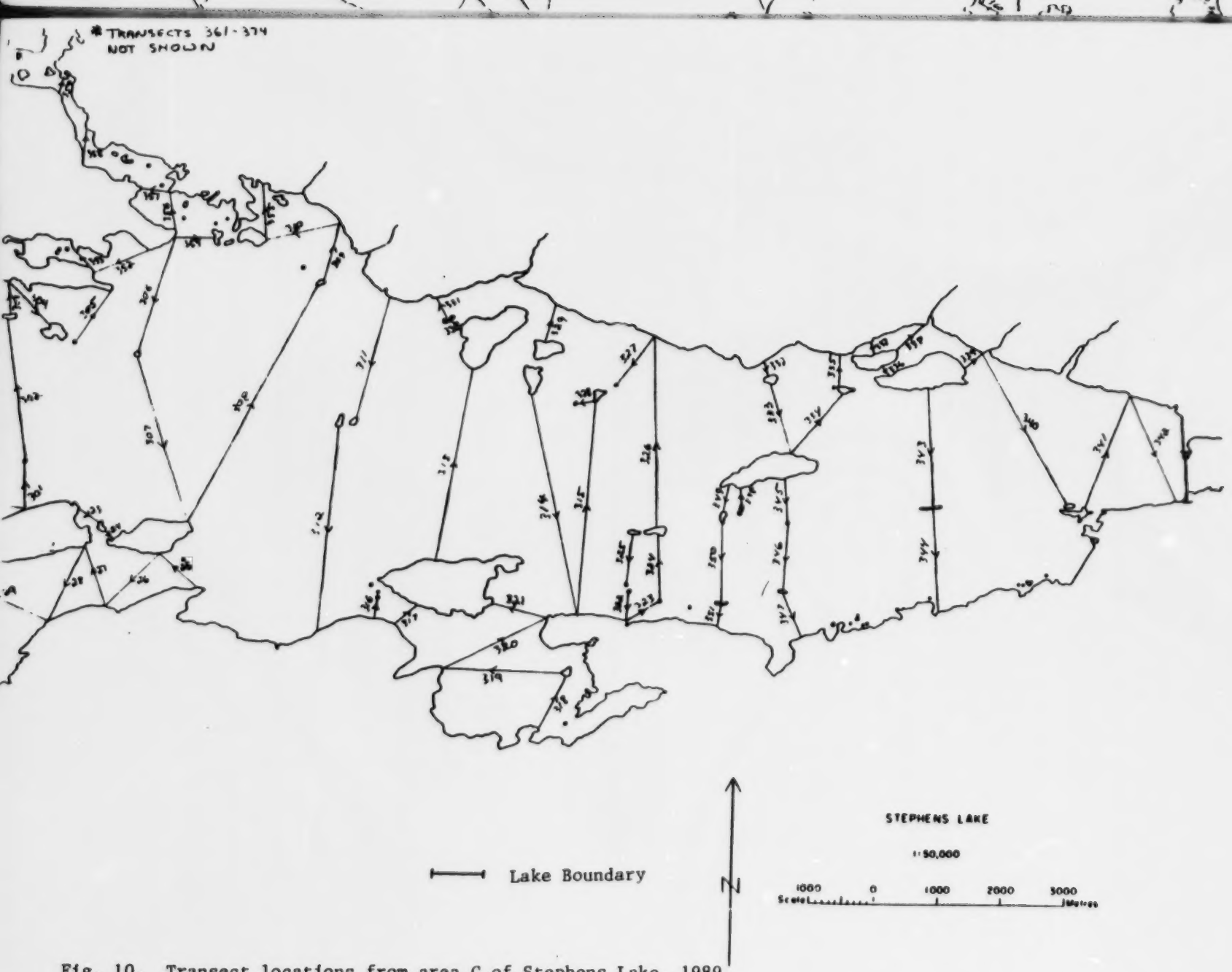

Fig. 10. Transect locations from area C of Stephens Lake, 1989.

in shaping the contours, as well as in extending contours into unsounded portions of the lakes. Original depth sounding tapes reduced to 70% original size for Split and Stephens lakes are shown in Appendices 1 and 2, respectively.

Planimetry

A Model HS 363 Hi-State Precision Coordinate Digitizer was used to determine lake, island and contour areas as well as shoreline lengths for Split and Stephens lakes. Calculations were done on maps with a scale of 1:50,000 for Split Lake and 1:37,500 for Stephens Lake.

Area calculations for Split and Stephens lakes were measured in hectares with a direct readout from the digitizer with no conversion necessary. Shoreline length for both lakes were measured in centimeters and then converted to kilometers. Shoreline, island and contour interval boundaries were measured twice with the average being used. Accuracy of the digitizer was significant to 0.001 for both area in hectares and length in centimeters.

Morphometry

Morphometric parameters were calculated using the methods described by Hutchinson (1957) and Welch (1948). The basic basin parameters used were chosen to coincide with those used by Brown (1974) to enable some comparison with past studies and to ensure standardized data presentation. Results for the various parameters were produced from data calculated from the bathymetric maps and depth sounding records.

RESULTS

Split Lake

Split Lake at an elevation of 166.5 m ASL has an approximate total area of 314.74 km^2, a water surface area of 269.83 km^2 and an island area totalling 44.91 km^2 (Table 1). The lake shoreline length is 417.86 km with an island shoreline length equalling 428.973 km. Shoreline development is fairly irregular with values of 6.65 without islands and 14.55 including islands. Mean depth of the lake basin is 4.48 m dropping to a maximum depth of 23 m. The total volume of Split Lake equals 1208.44 $m^3 \times 10^6$ at a water elevation of 166.5 m (Table 2). The areas contained by each contour interval are also shown in Table 2.

Caution is advised when reviewing the morphometric and bathymetric results for Split Lake. Due to unfavourable weather conditions during the 1989 field season only 47 transects could be completed. Expectations of using a bathymetric map from a previous study (Schlick, 1968) to complete unsounded portions of Split Lake in 1989 was hindered because of discrepancies found between the present sounding results and Schlick's (1968) results which couldn't be totally explained by differences in water elevation (166.5 m and 168.2 m respectively) during the two depth sounding periods. The increased water elevation of Split Lake during Schlick's (1968) study was the result of increased discharge through the Kelsey Generating Station. The highest historical monthly mean discharge rate for the Kelsey Generating Station (Station No. 05uE005) was recorded during July, 1966; as well, the highest annual mean discharge rate was recorded during the same year.

Table 1. General morphometric parameters for Split and Stephens lakes, 1989.

	Post-flood		Pre-flood	
	Split Lake	Stephens Lake	Split Lake	Stephens Lake[1]
Total lake area Km^2	314.74	421.33	283.9	—
Total water surface area Km^2	269.83	364.70		101.5
Total island area Km^2	44.91	56.63		—
Number of islands	476	513		—
Lake shoreline length Km	417.86	461.28		—
Island shoreline length Km	428.97	477.10		—
Total shoreline length Km	846.84	938.38		—
Shoreline development	6.65	6.34		—
Shoreline development incl. islands	14.55	13.87		—
Maximum depth m	23	35	29.9	—
Mean depth m	4.48	7.63	7.01	—
Mean depth ÷ maximum depth	.20	.22	.23	—
Altitude above sea level (ASL) (m)	166.5	139.13	168.2	—
Number of transects	47	355	147	—

1. Data calculated from waterbodies existing prior to impoundment and now are encompassed by the Stephens Lake Reservoir. These waterbodies include Big and Little Moose lakes, the Nelson River below Lower Gull Rapids and other small waterbodies.

Table 2. Contour areas and volume for Split Lake, 1989.

Split Lake	Post-flood	Pre-flood
Area of 0 m contour (Km^2)	269.83	N/A
Area of 3 m contour (Km^2)	152.24	
Area of 6 m contour (Km^2)	66.98	
Area of 9 m contour (Km^2)	32.78	
Area of 12 m contour (Km^2)	14.53	
Area of 15 m contour (Km^2)	6.90	
Area of 18 m contour (Km^2)	2.07	
Area of 21 m contour (Km^2)	.37	
Volume ($m^3 \times 10^6$)	1208.44	

To facilitate the production of a bathymetric map for Split Lake and to calculate morphometric parameters, depth sounding results produced by MacLaren Plansearch Inc. and Beak Consultants Ltd. (1988) were used to aid in the contour mapping. Transect locations from the MacLaren and Beak (1988) report are shown in Fig. 11.

Depth sounding results produced by the MacLaren and Beak (1988) study and the present Ecological Monitoring study were corroborated by water depths recorded from gillnet set locations in the vicinity of depth sounding transects from both studies. Water depths at net set locations were recorded during 5 years of Ecological Monitoring field operations, 1985-1989. In areas of Split Lake which were not depth sounded by either the Ecological Monitoring study or the MacLaren and Beak (1988) study, Schlick's (1968) results were interpreted and adjusted accordingly. Interpretation and adjustment was based on information from net set water depths and random sounding results during field operations over the 5 year period of the Ecological Monitoring study. However, a finalized bathymetric map for Split Lake will not be included in this report; a recommedation with regards to the bathymetry and morphometry of Split Lake is presented later in this report.

Stephens Lake

Stephens Lake at a water level of 139.13 m ASL has an approximate total area of 421.33 km^2, a water surface area of 364.70 km^2 and an island area of 56.63 km^2 (Table 1). The lake shoreline length totals 461.28 km and an island shoreline length totalling 477.10 km. Shoreline development of Stephens Lake is quite irregular with values of 6.34 without islands and 13.87 including

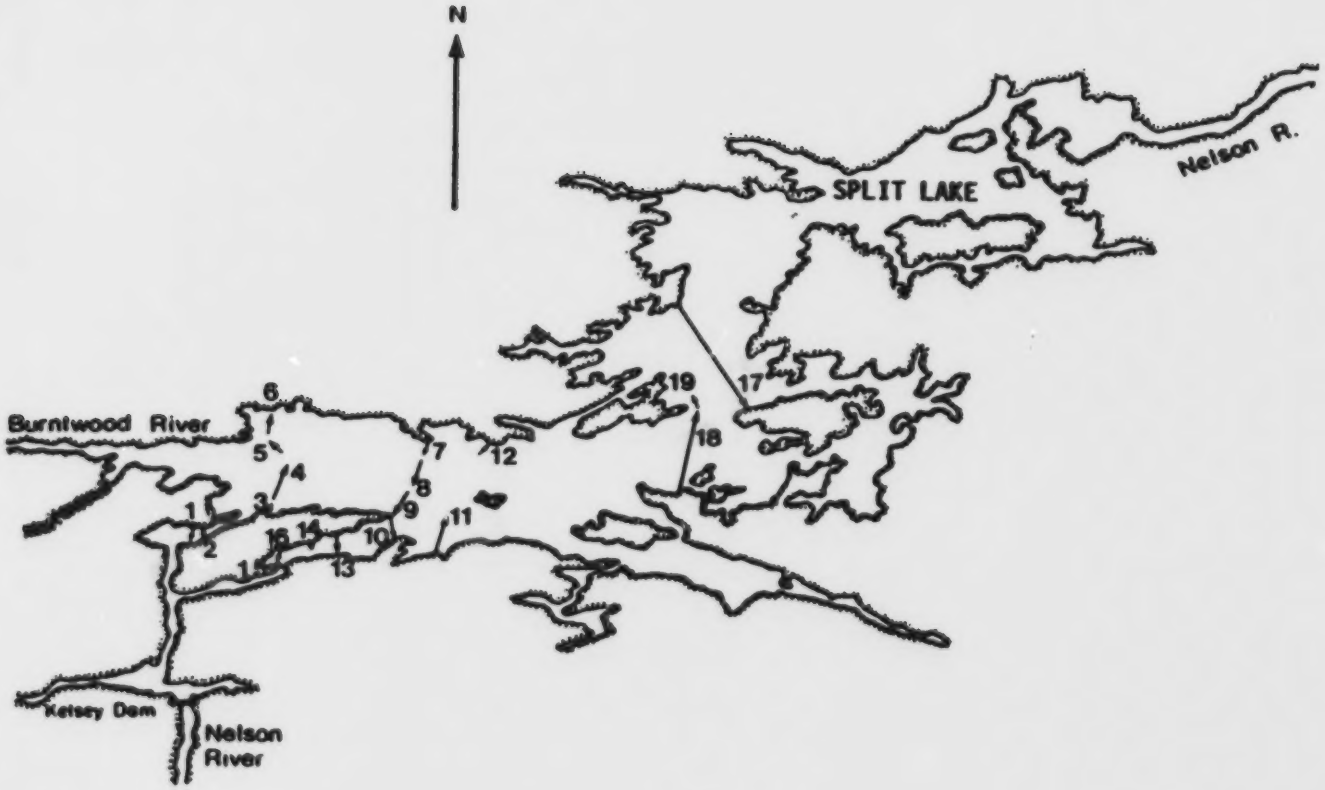

Fig. 11. Transect locations for Split Lake in 1987, (MacLaren and Beak, 1988).

islands. Mean depth of Stephens Lake is 7.63 m with a maximum depth of 35 m. The total volume at a water level of 139.13 m equals 2782.35 $m^3 \times 10^6$ (Table 3). The contour interval and the areas contained in each are also shown in Table 3.

Table 3. Contour areas and volume for Stephens Lake, 1989.

Stephens Lake	Post-flood	Pre-flood
Area of 0 m contour (Km^2)	364.70	101.50
Area of 5 m contour (Km^2)	197.43	—
Area of 10 m contour (Km^2)	103.56	—
Area of 15 m contour (Km^2)	51.86	—
Area of 20 m contour (Km^2)	21.14	—
Area of 25 m contour (Km^2)	9.02	—
Area of 30 m contour (Km^2)	1.64	—
Volume ($m^3 \times 10^6$)	2782.35	—

RECOMMENDATION

1. That Split Lake be depth sounded in its entirety to allow the production of an accurate bathymetric map and ensure greater confidence in the calculation of morphometric parameters for Split Lake.

ACKNOWLEDGEMENTS

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A special thanks to Jeanette Forte for typing this report.

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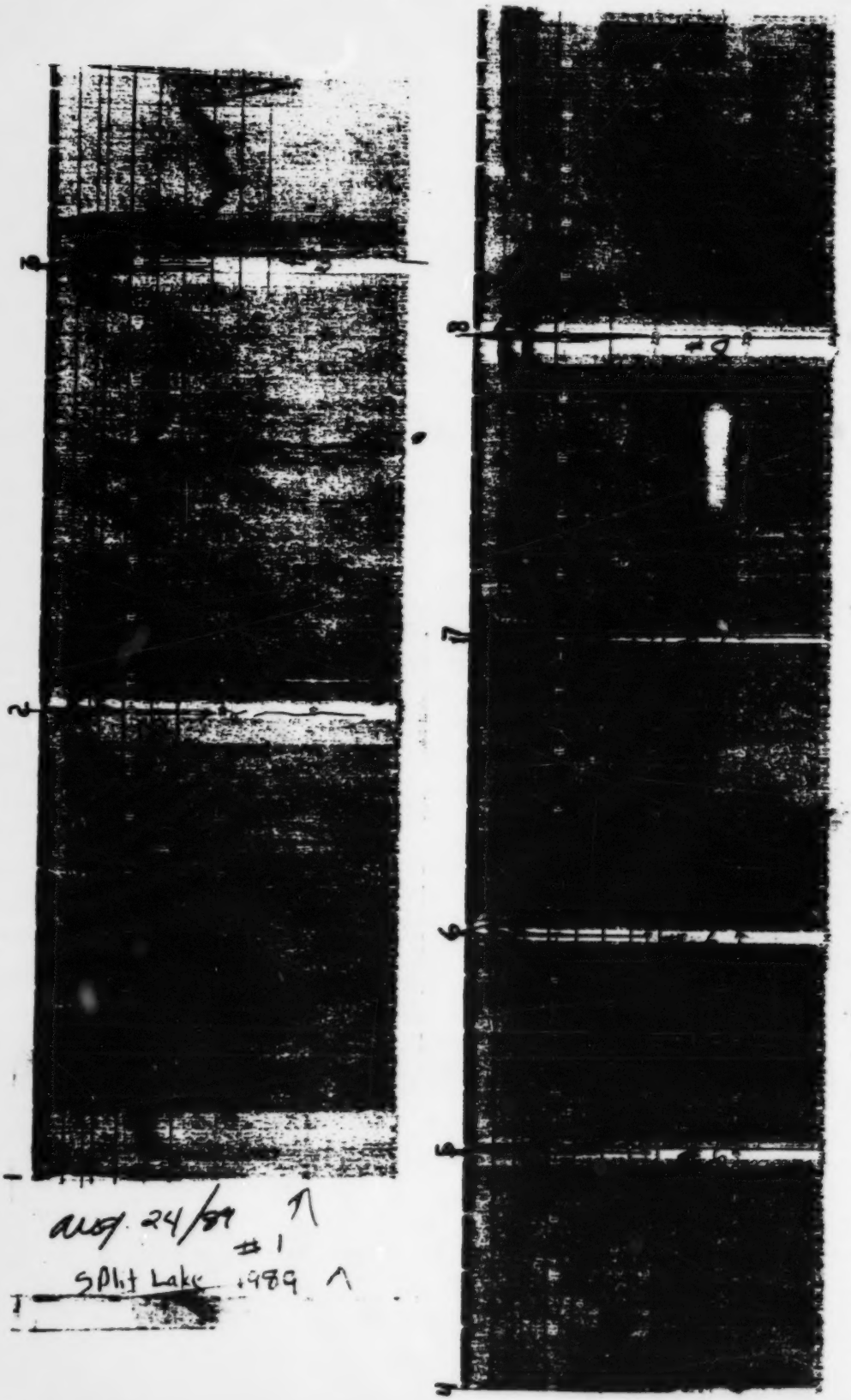
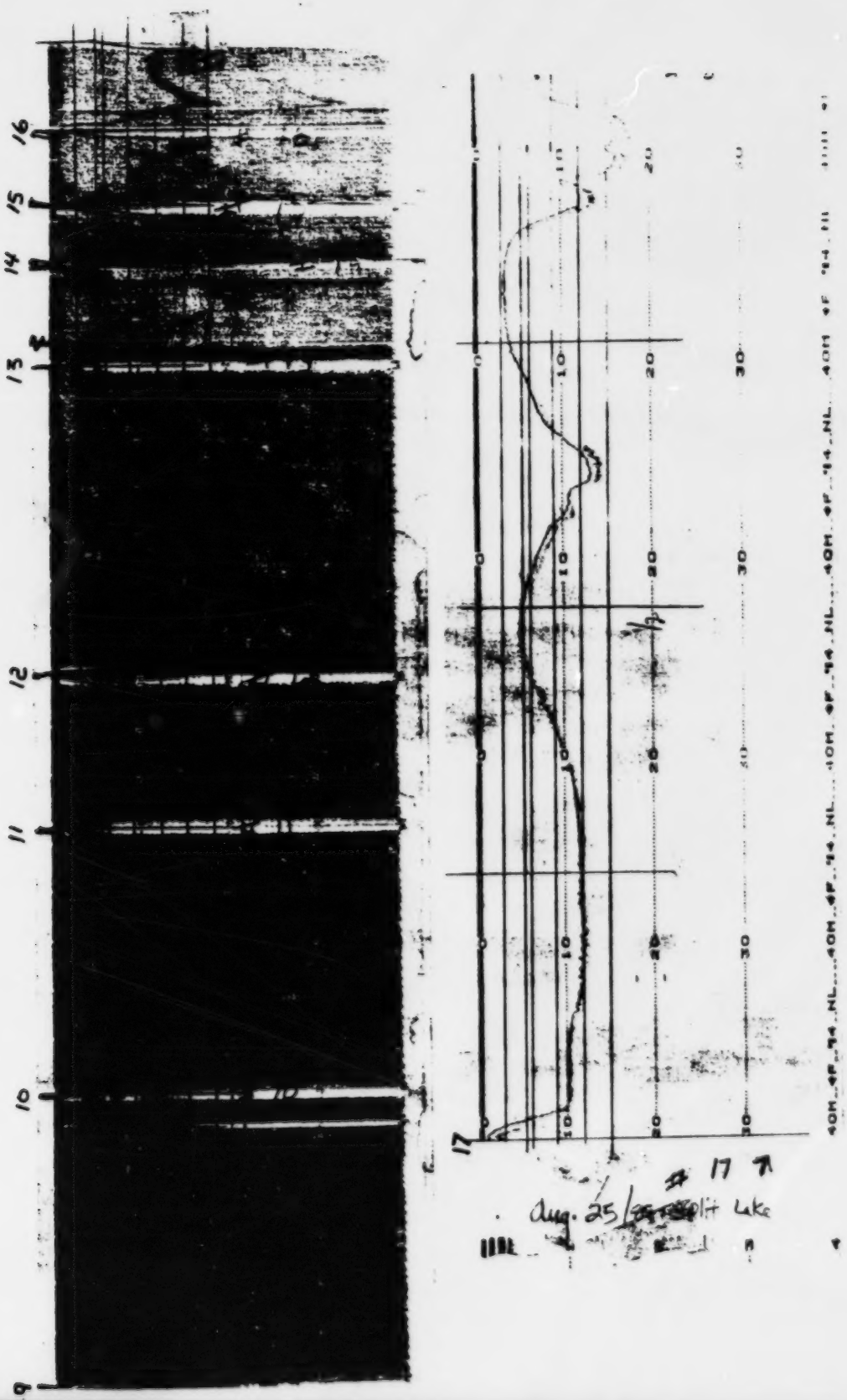
Appendix 1. Original depth sounding transect records for Split Lake, 1989, reduced to 70% of original size.

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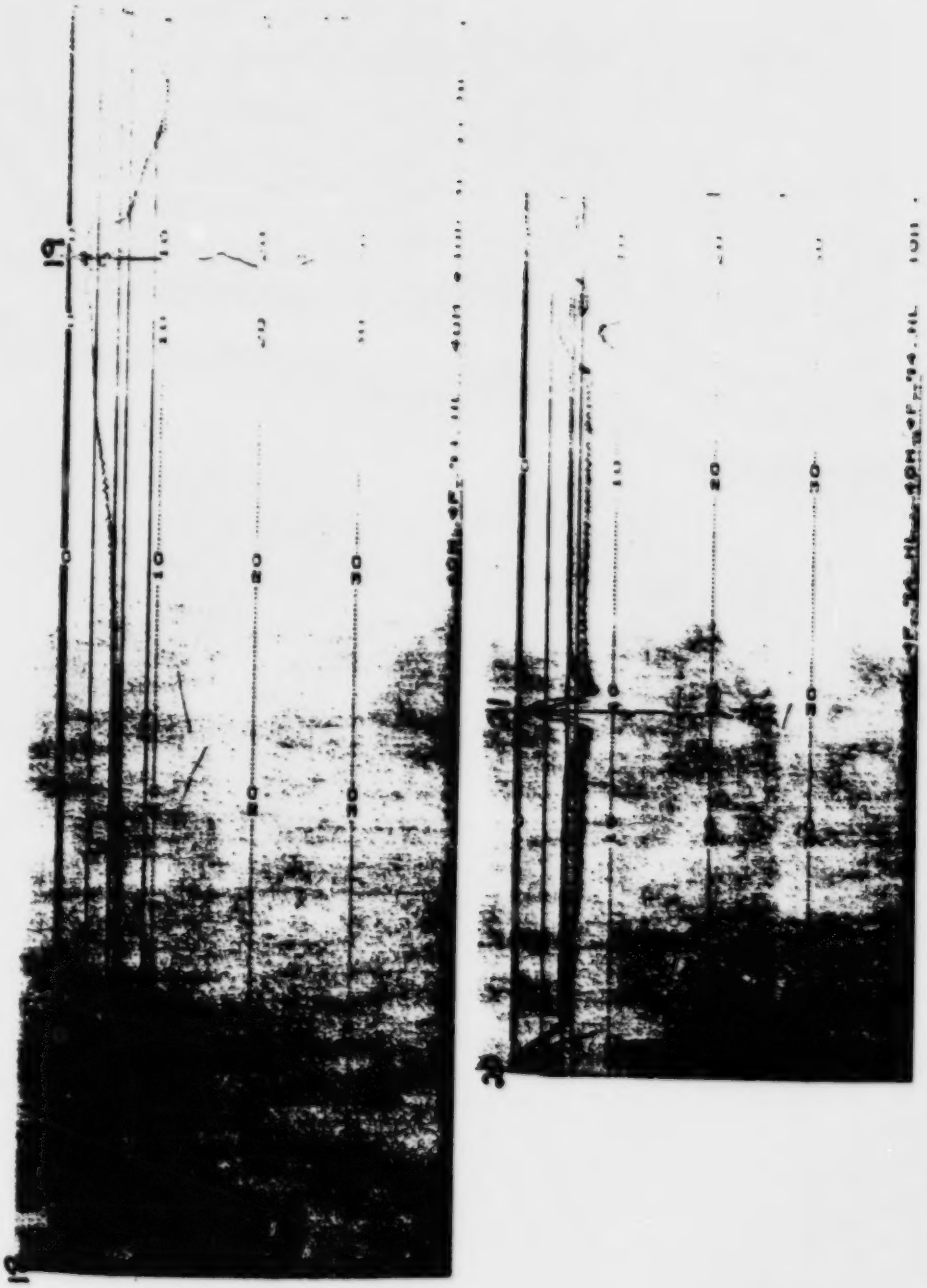

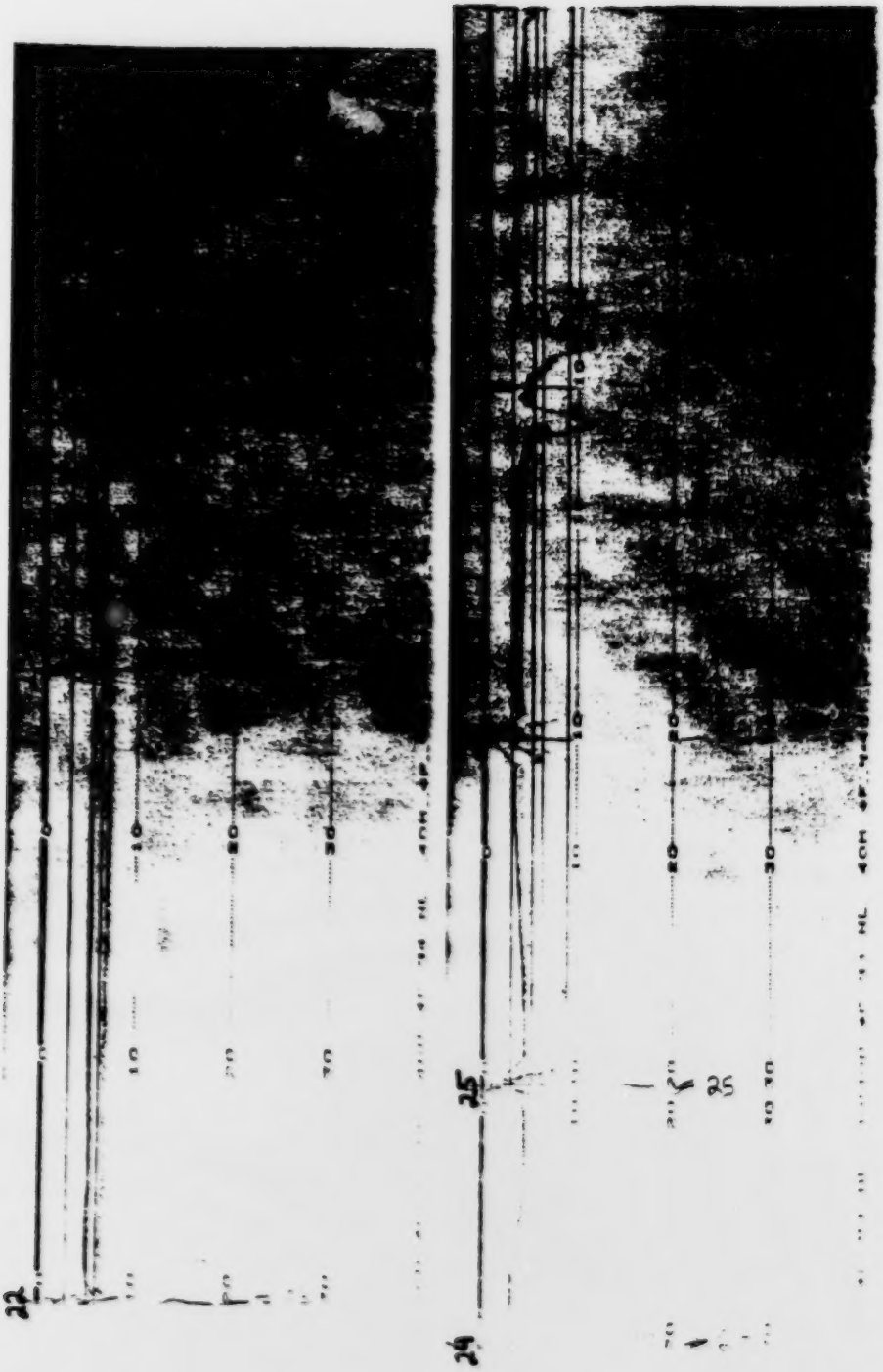
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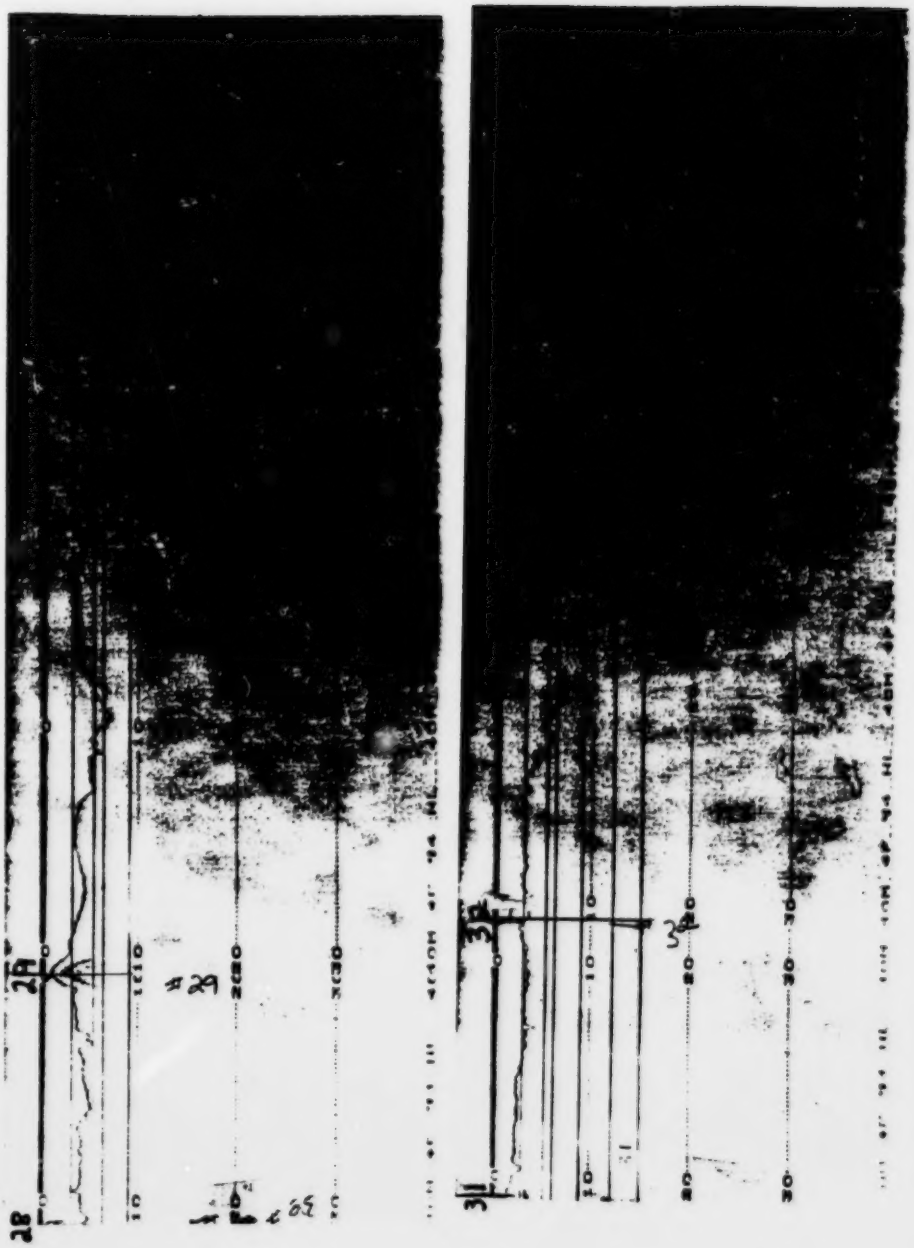

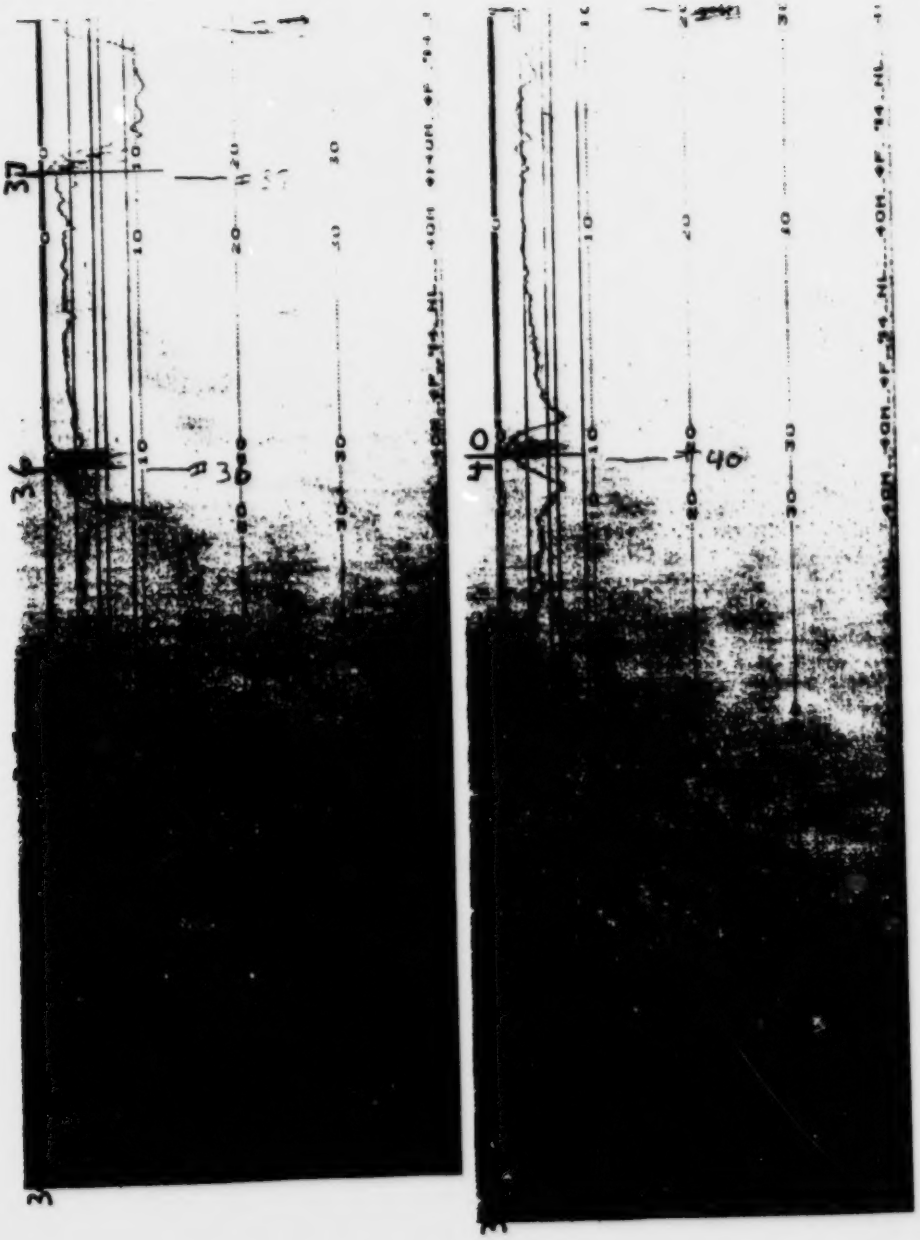
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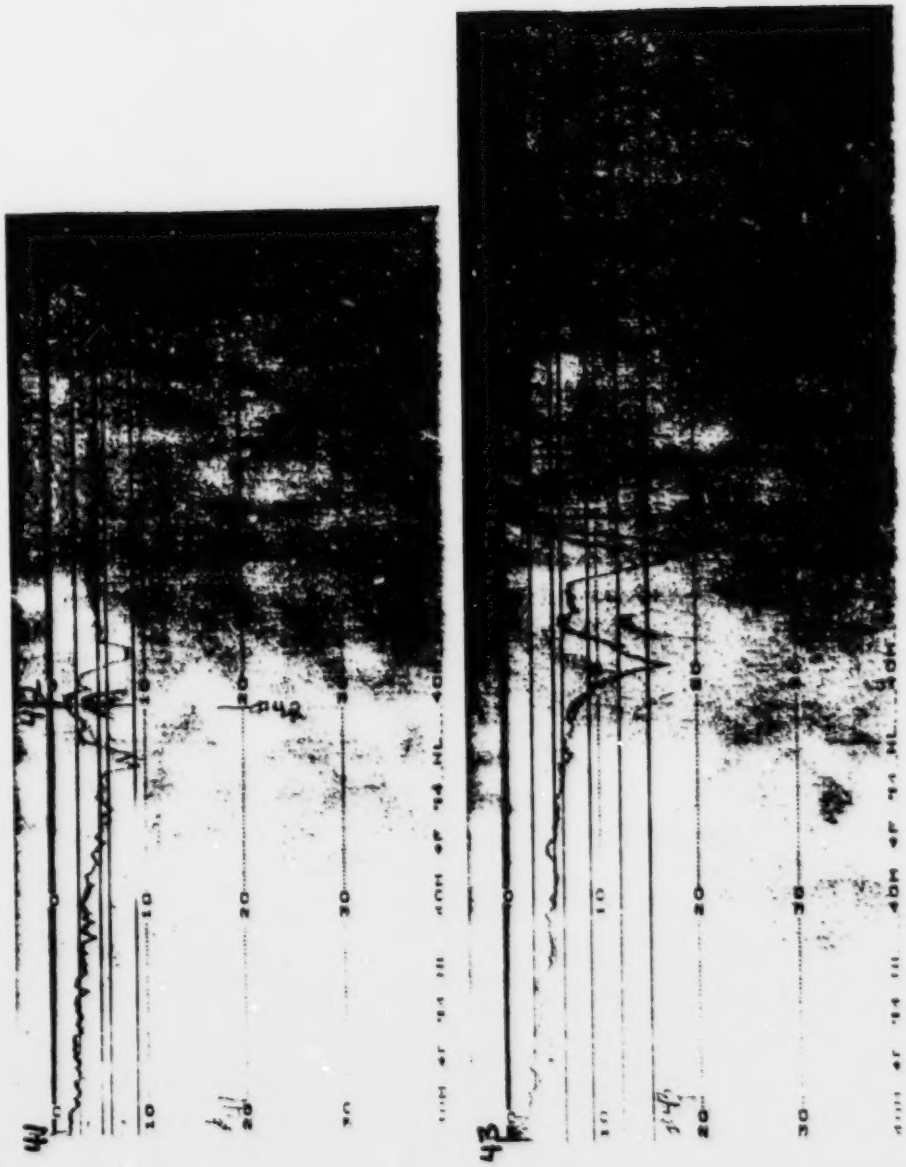
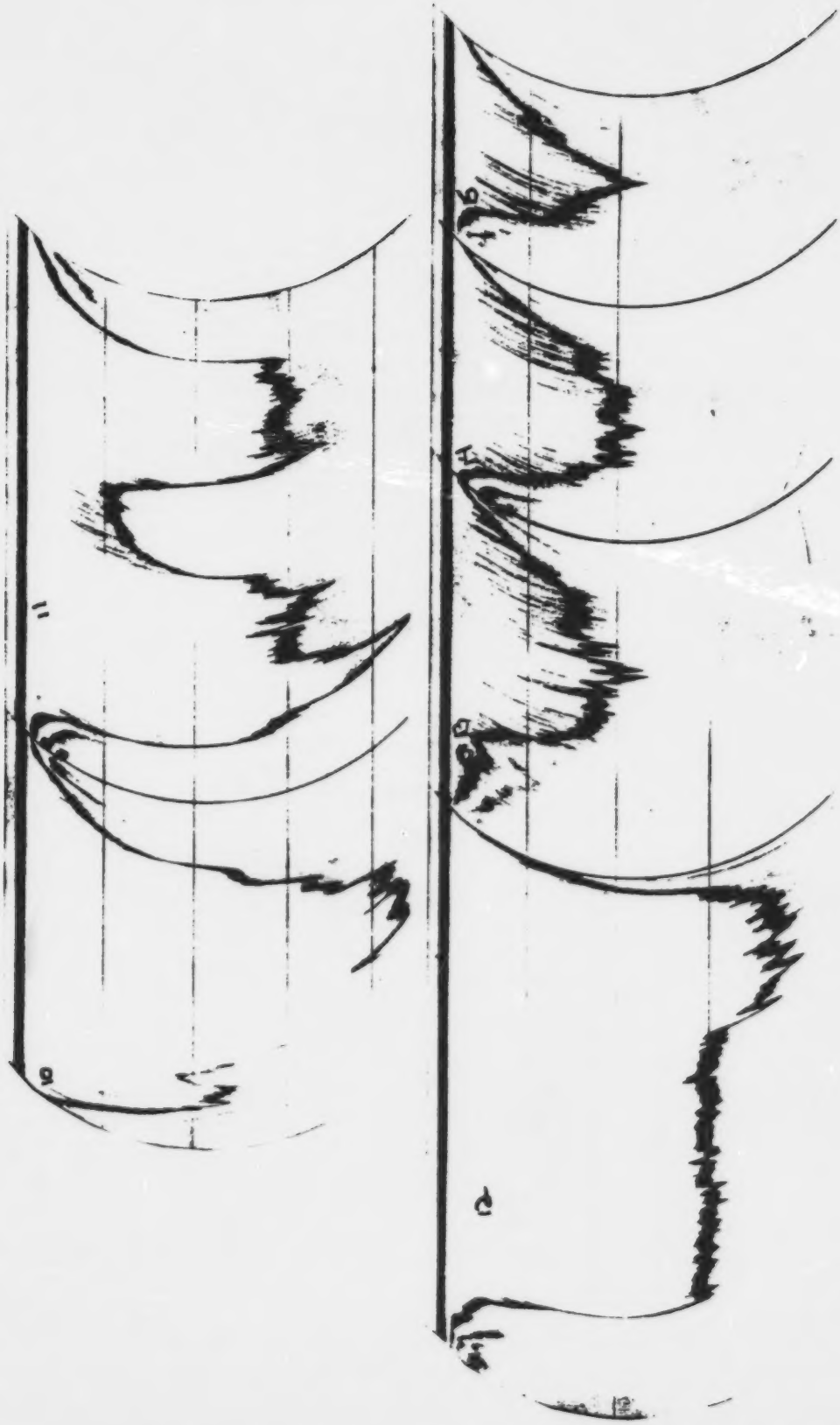
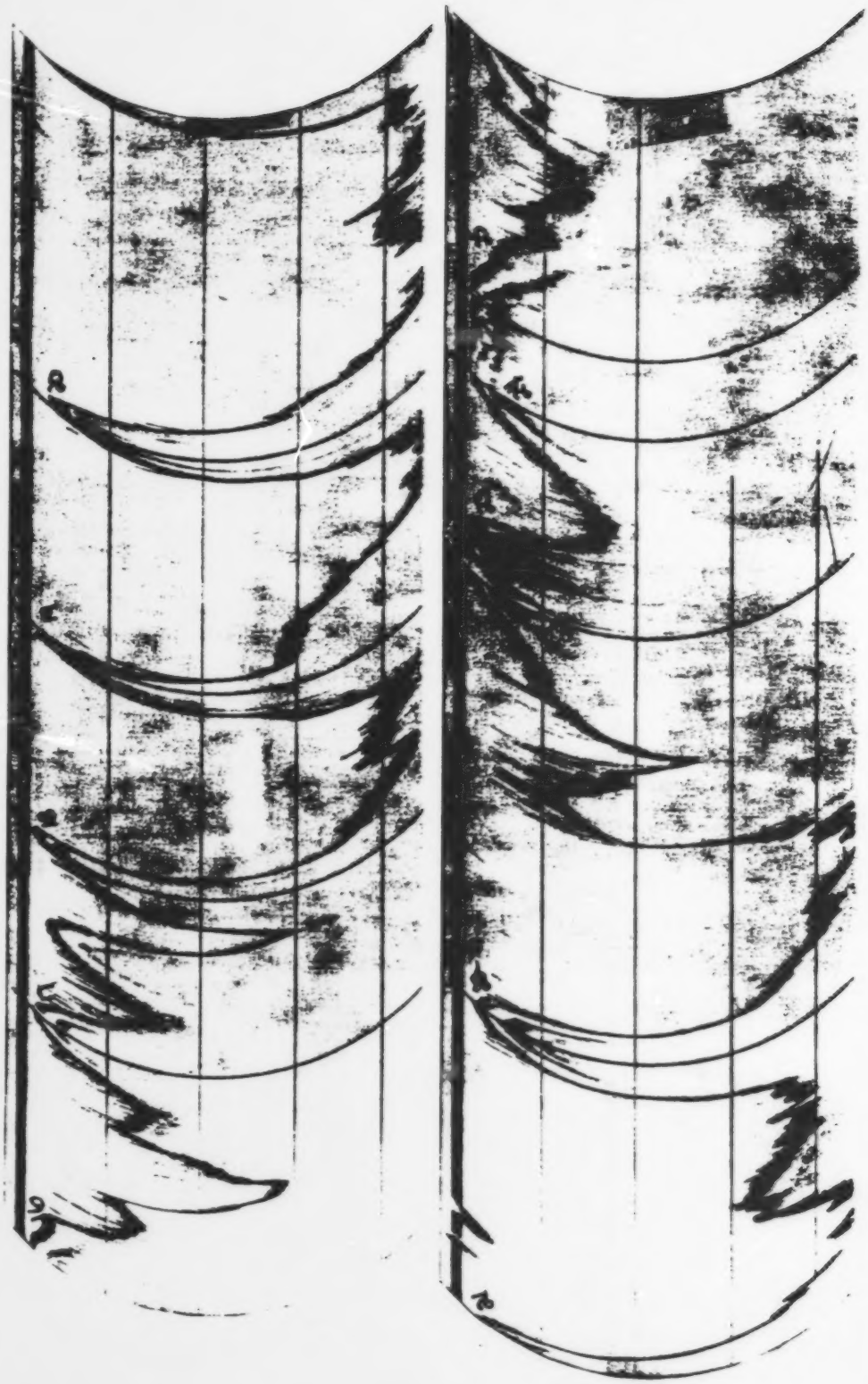
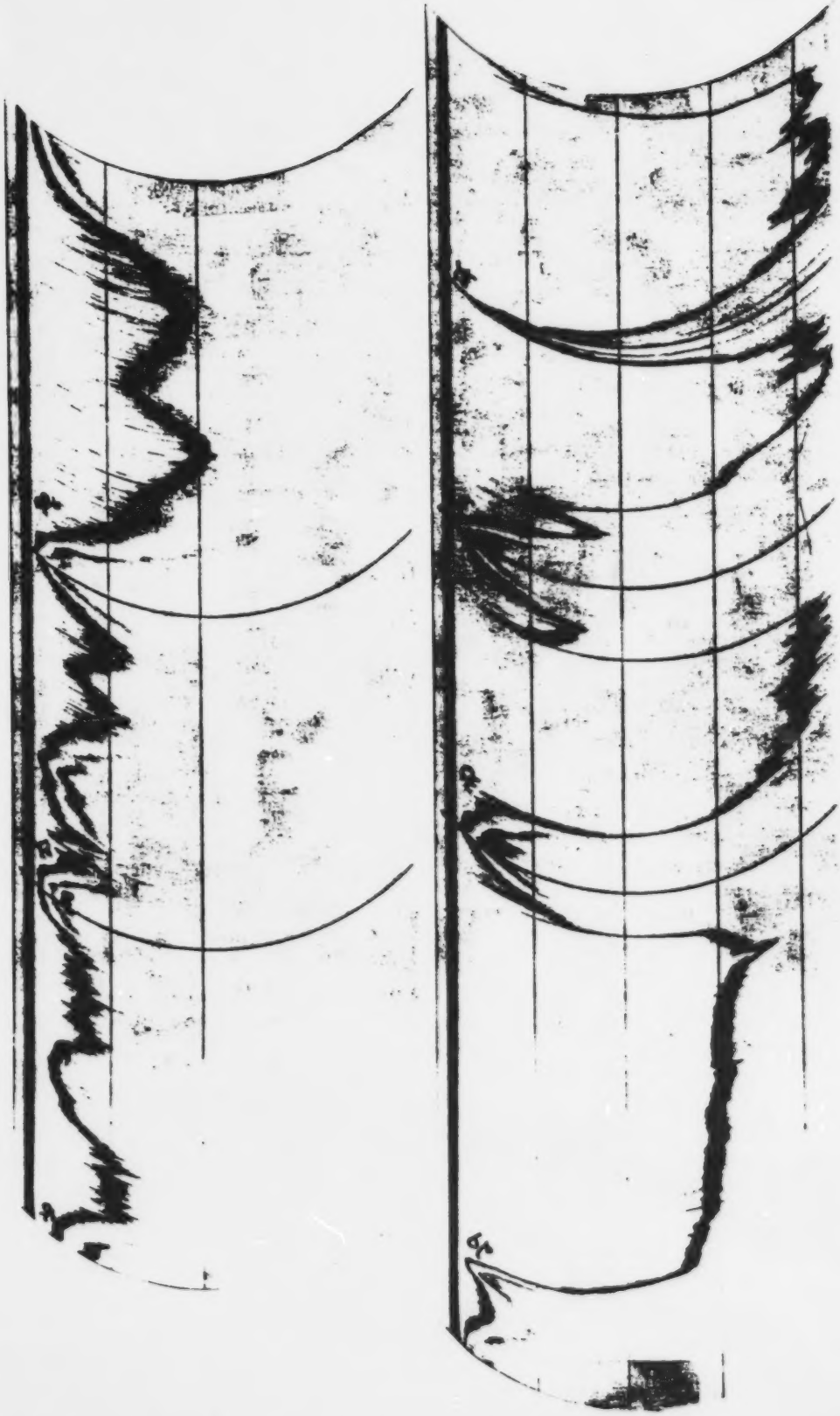


Appendix 2. Original depth sounding transect records for Stephens Lake, 1989, reduced to 70% of original size.







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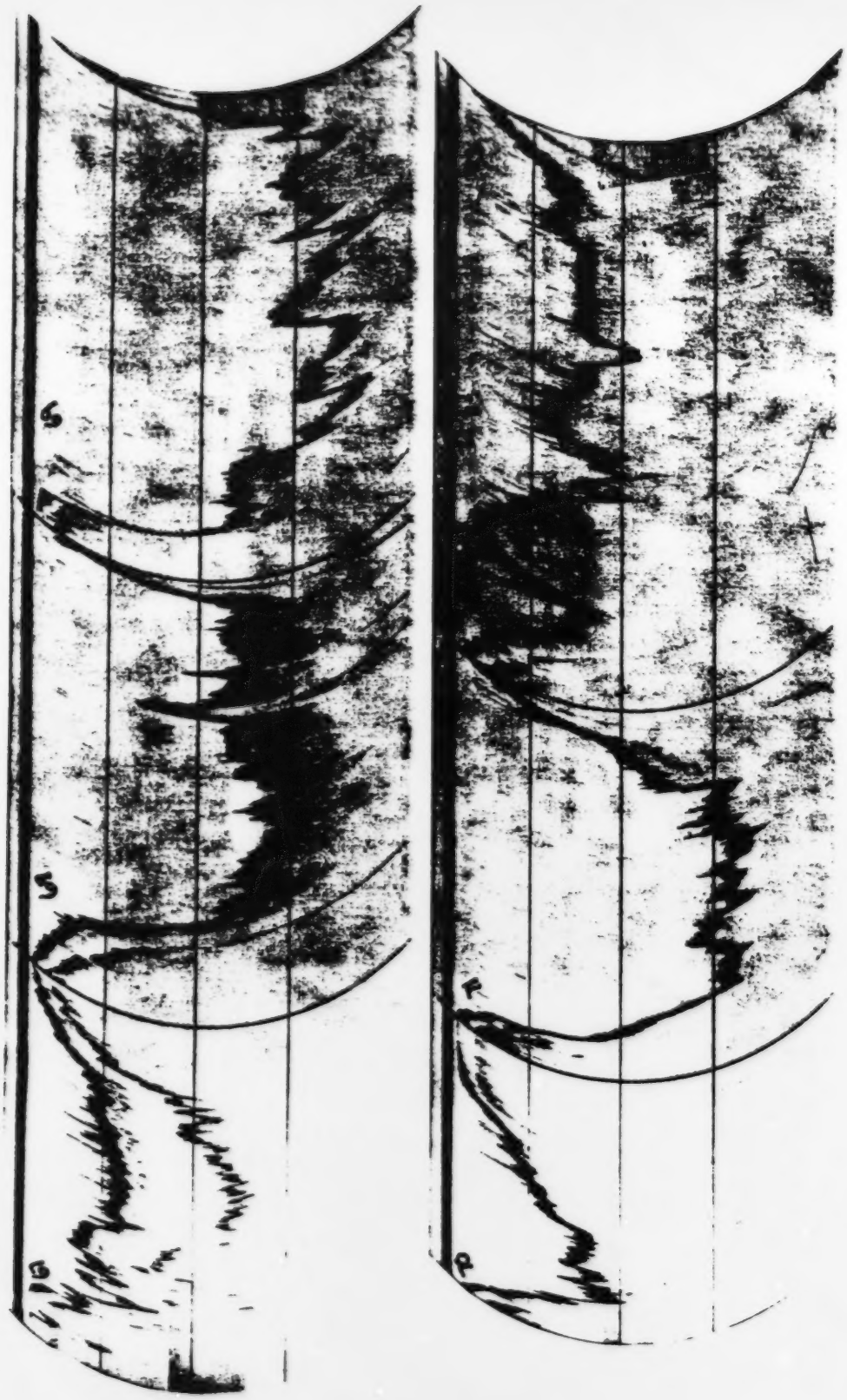
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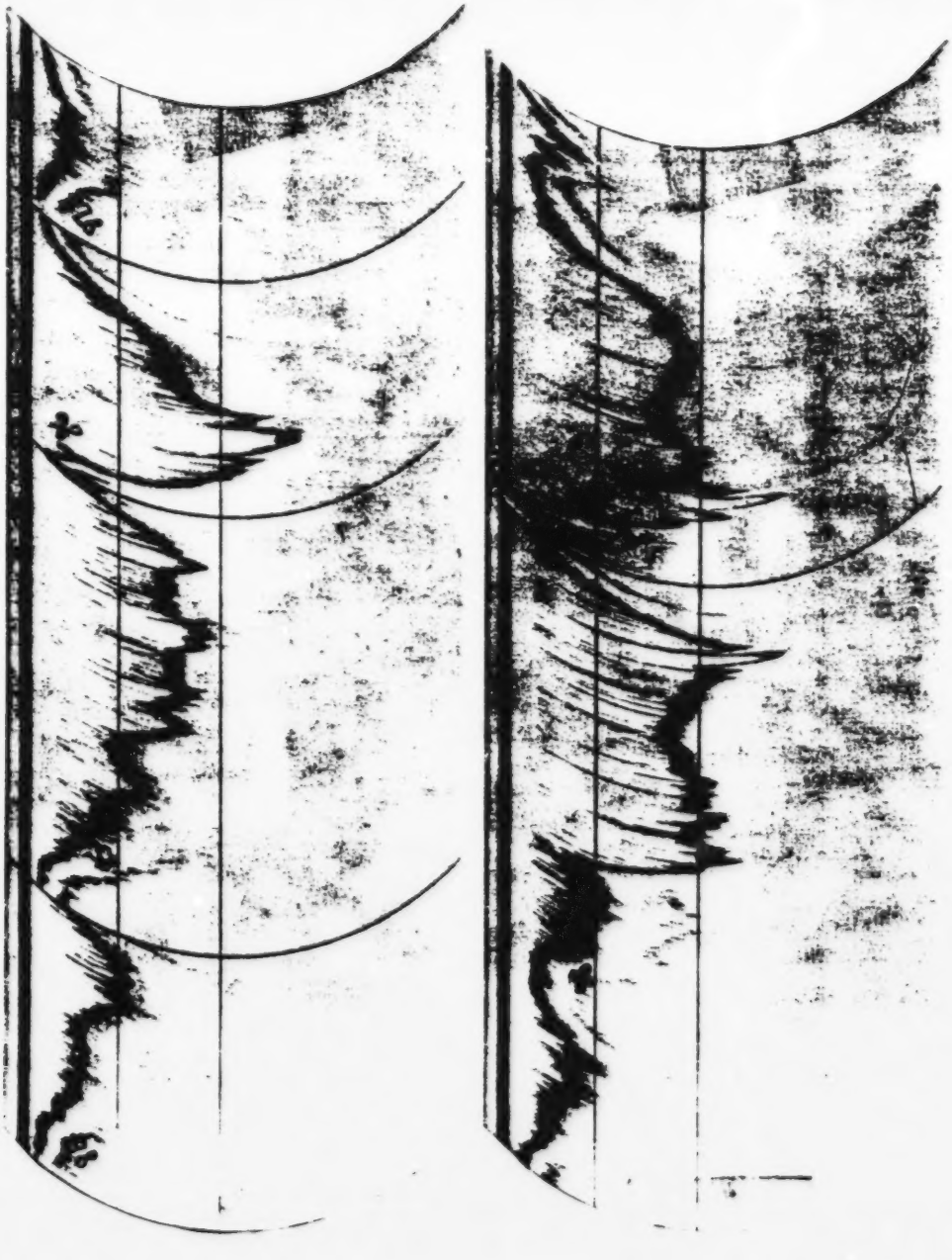

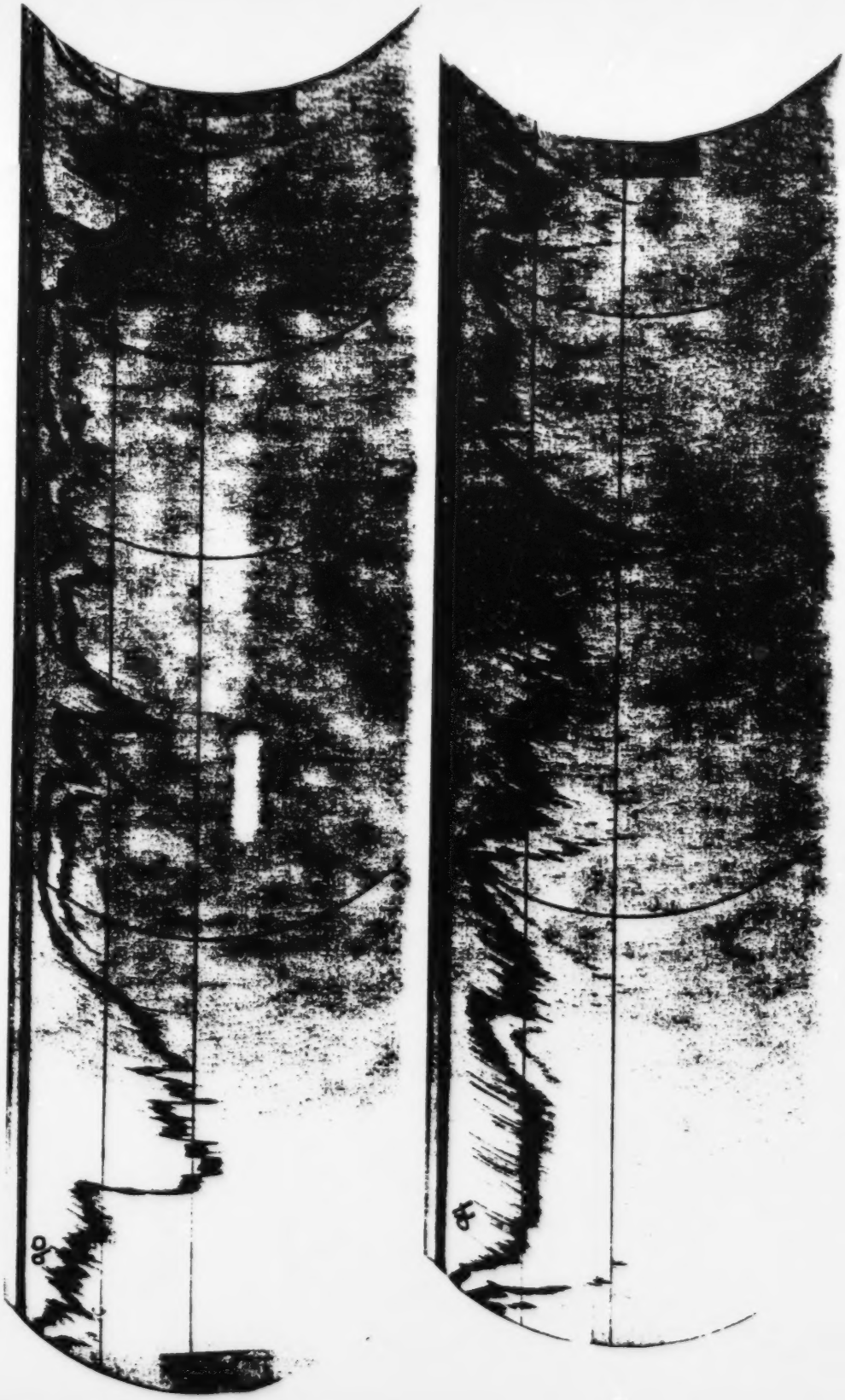

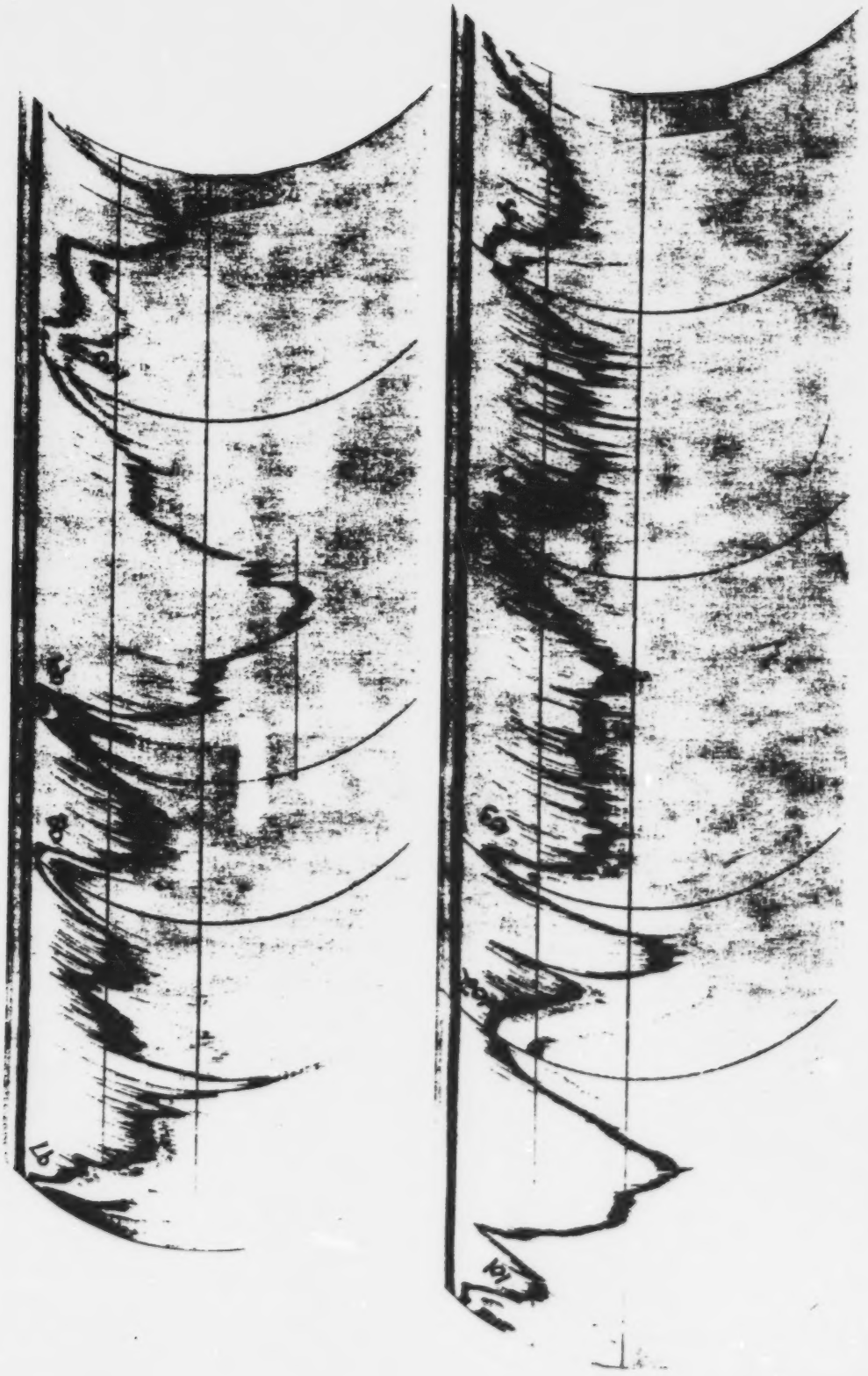

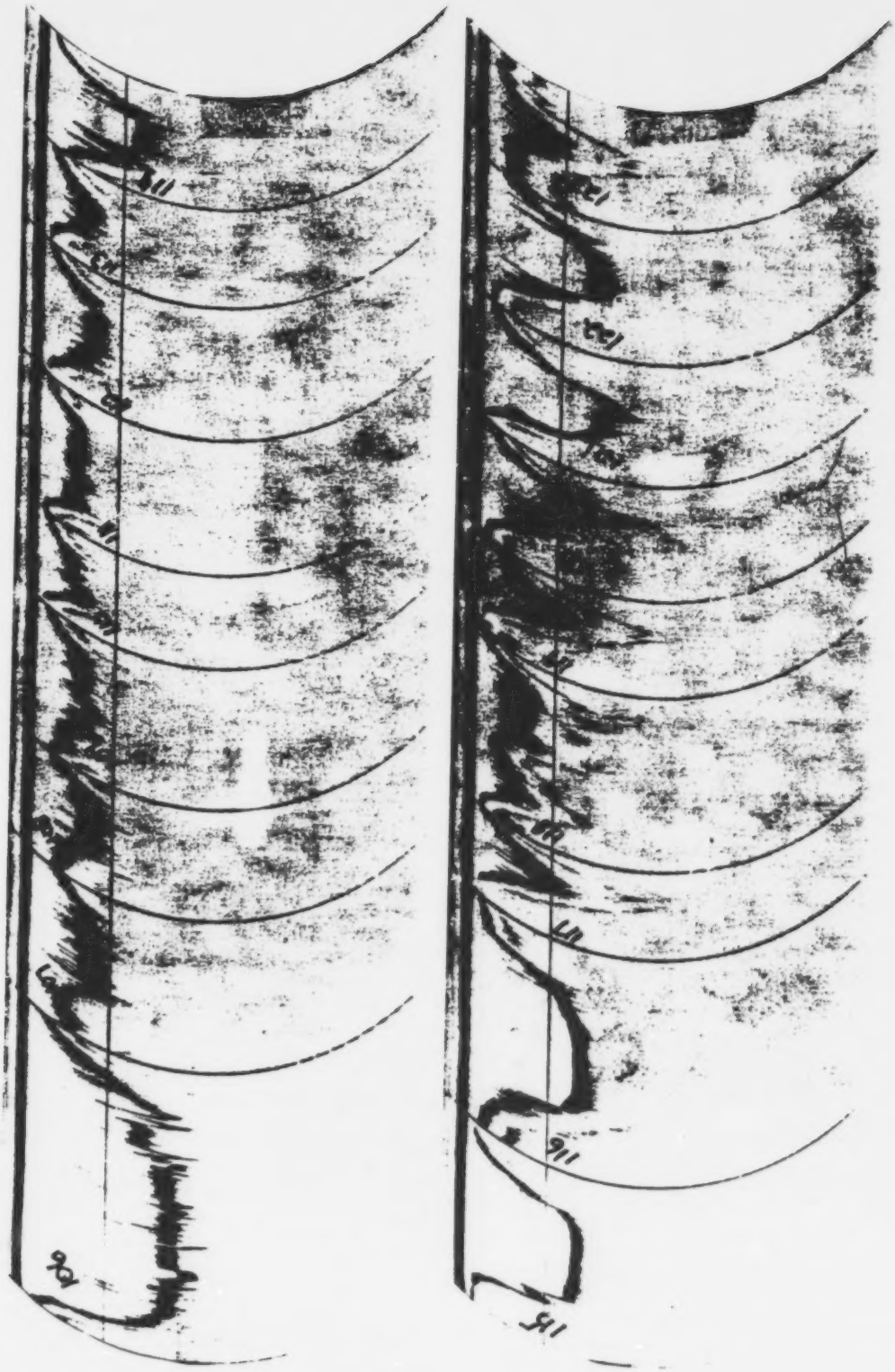

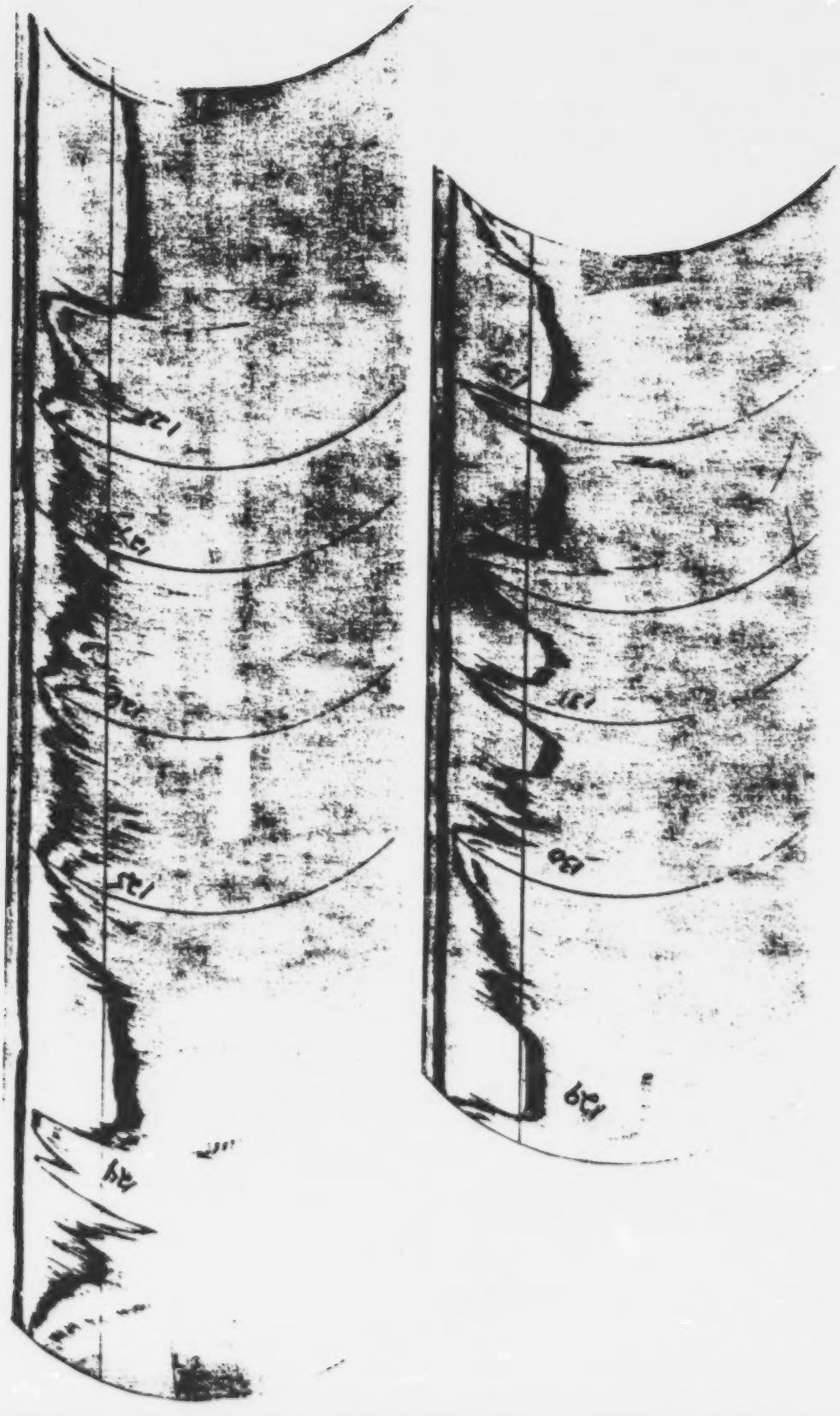

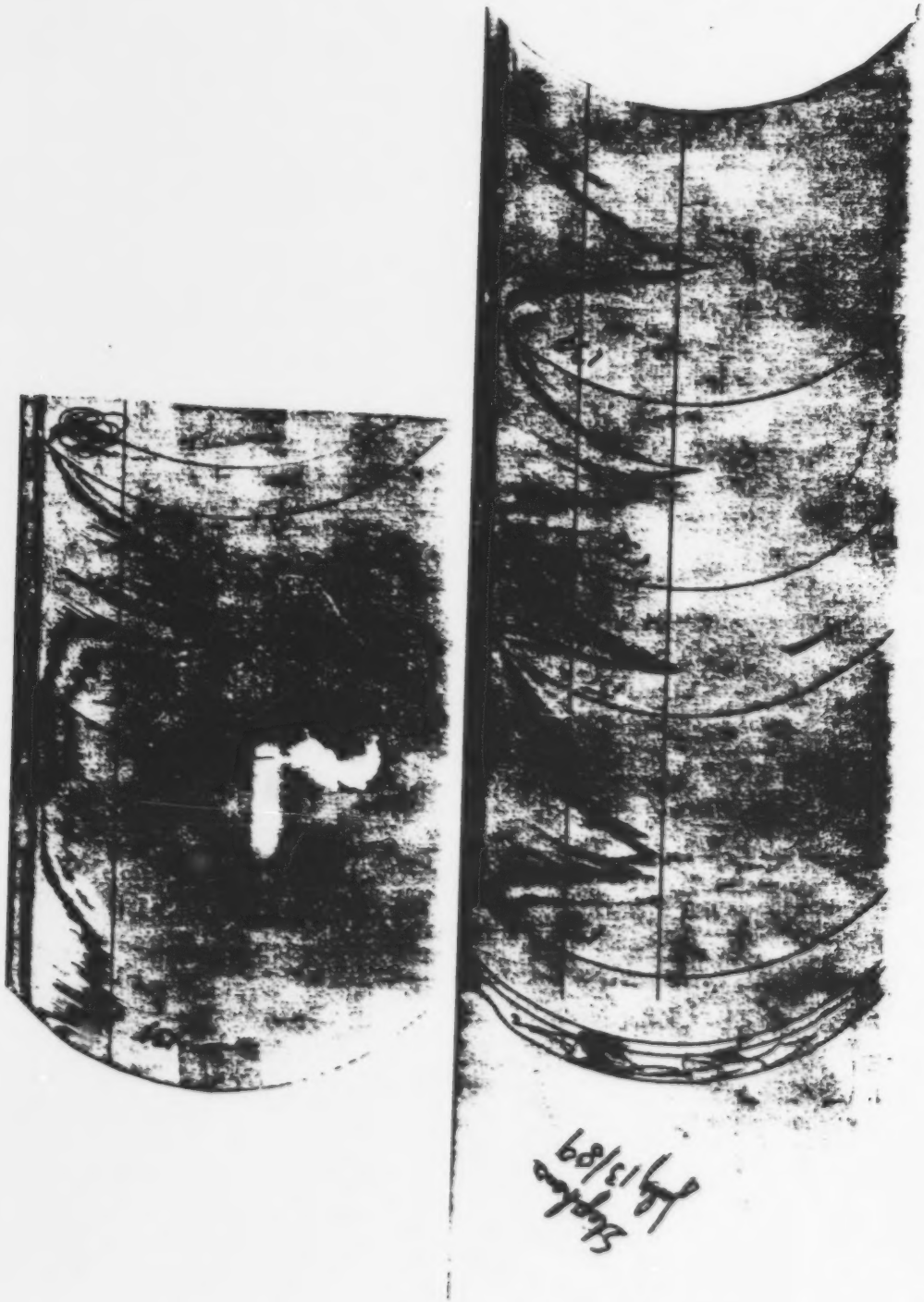

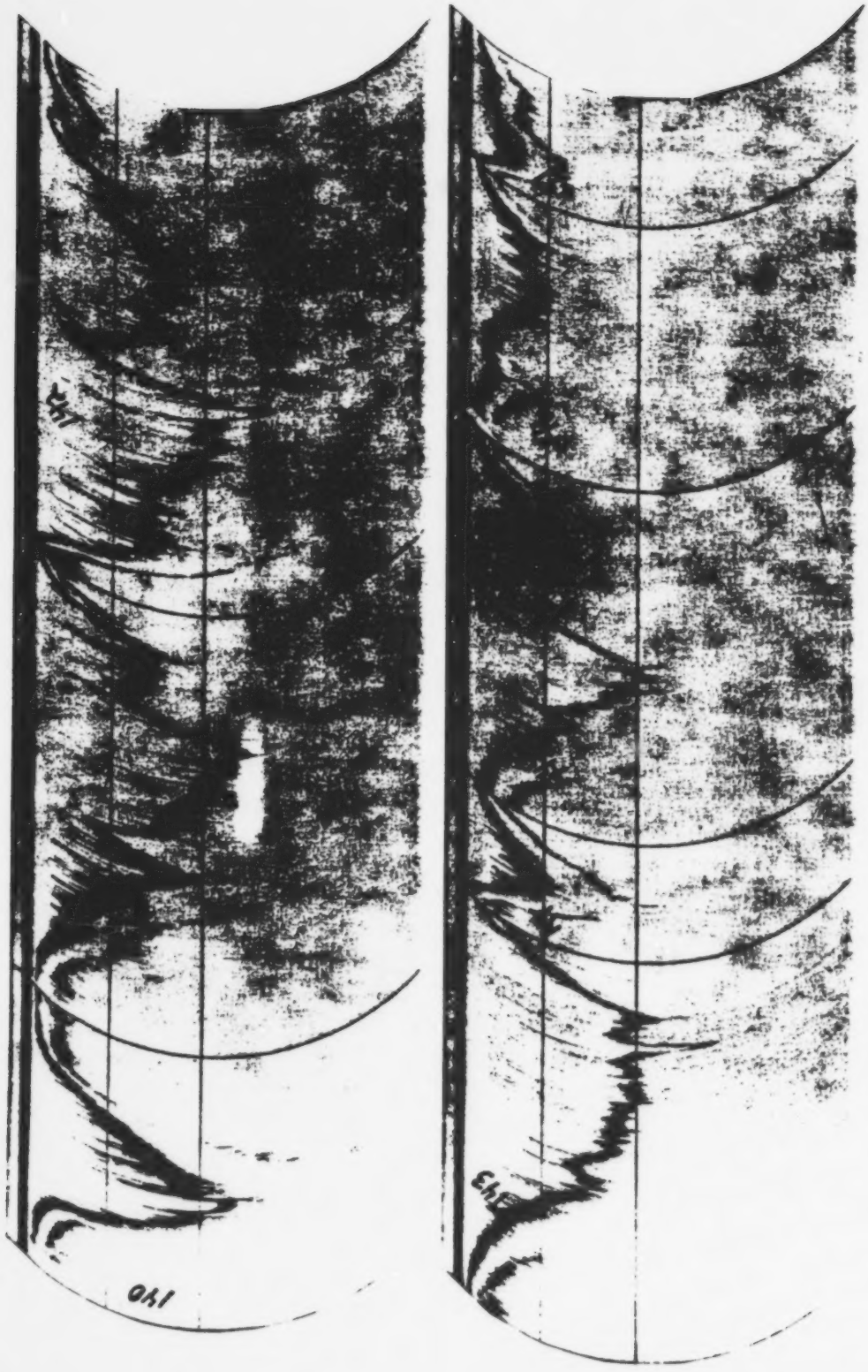
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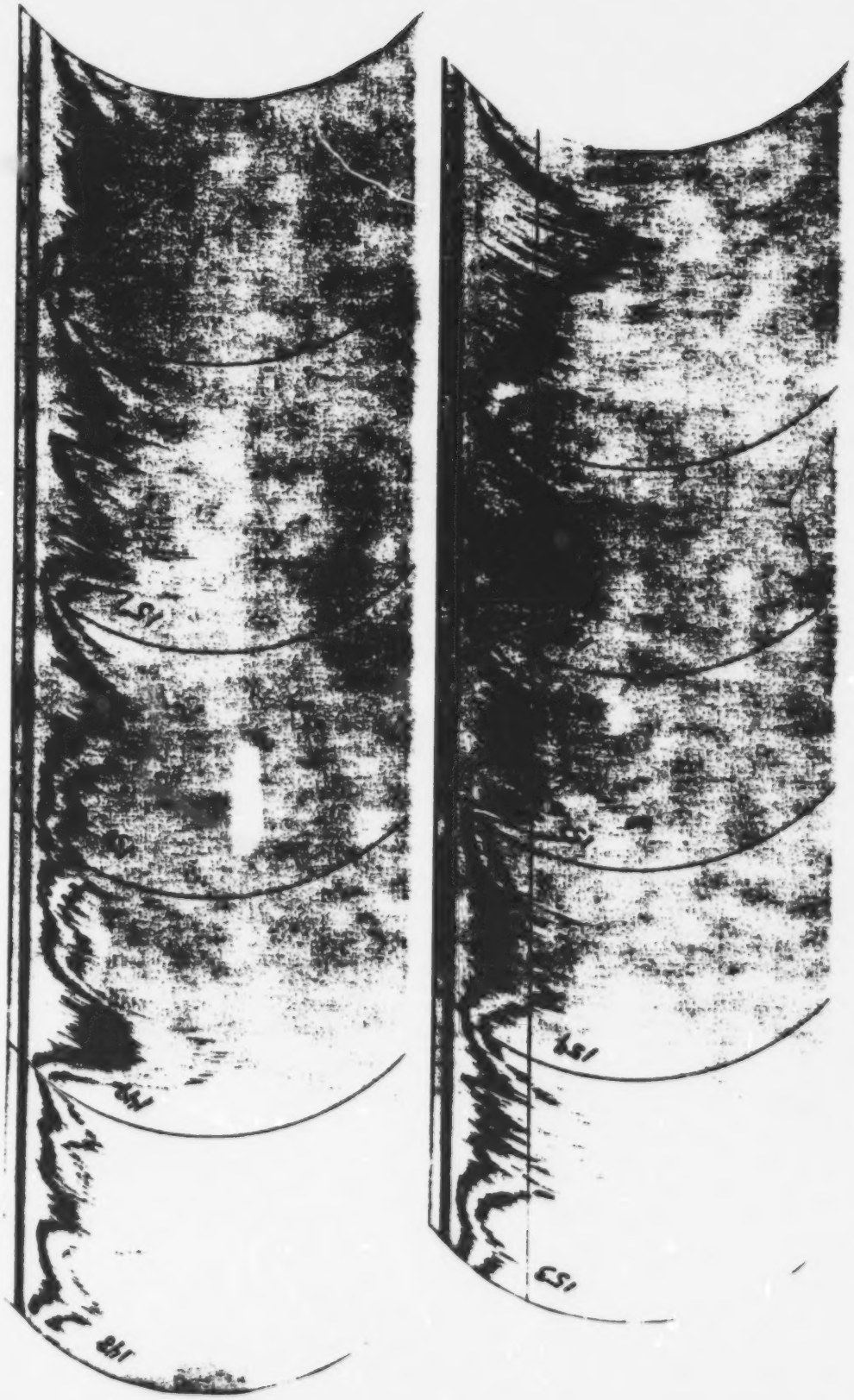
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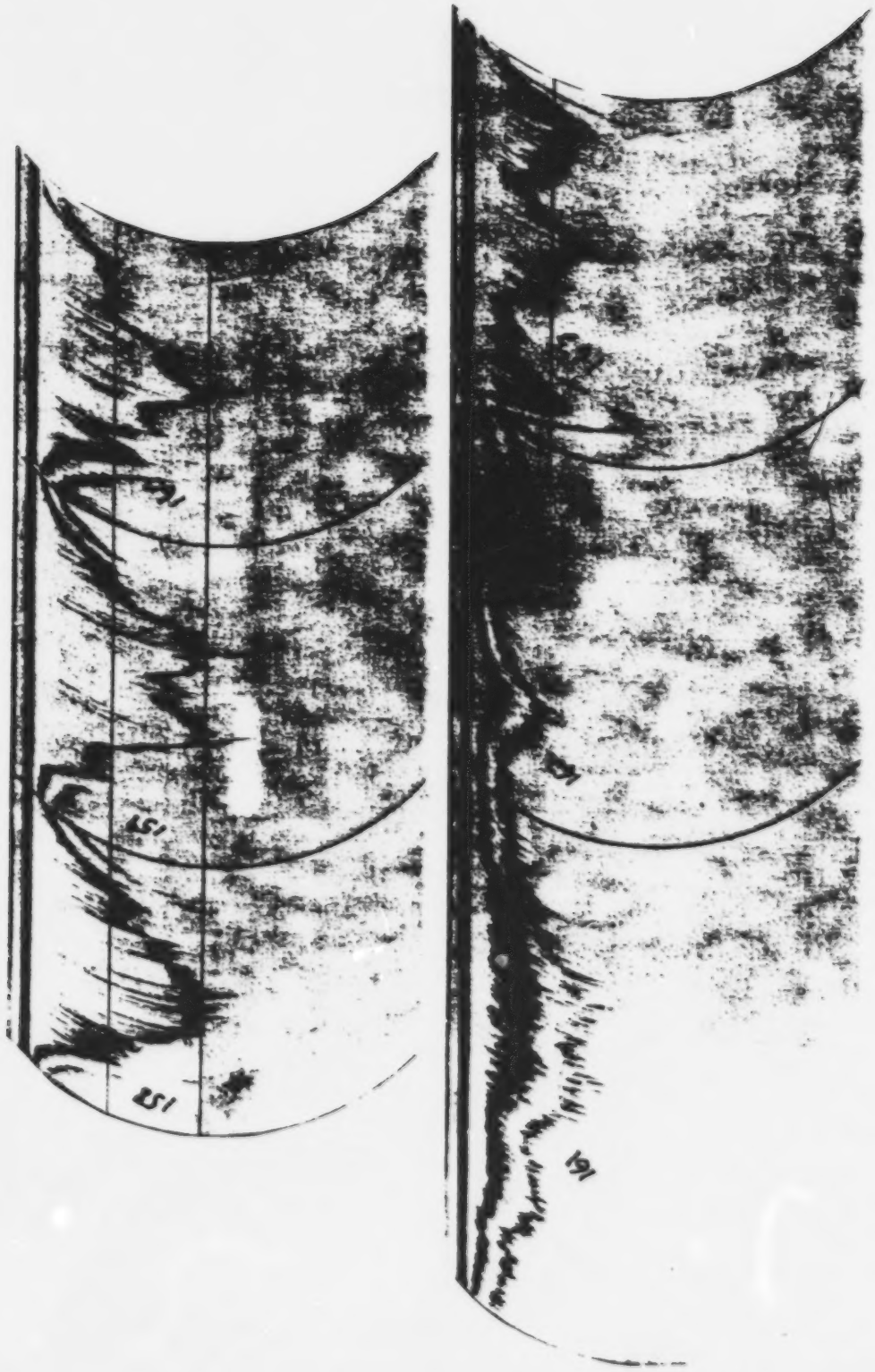
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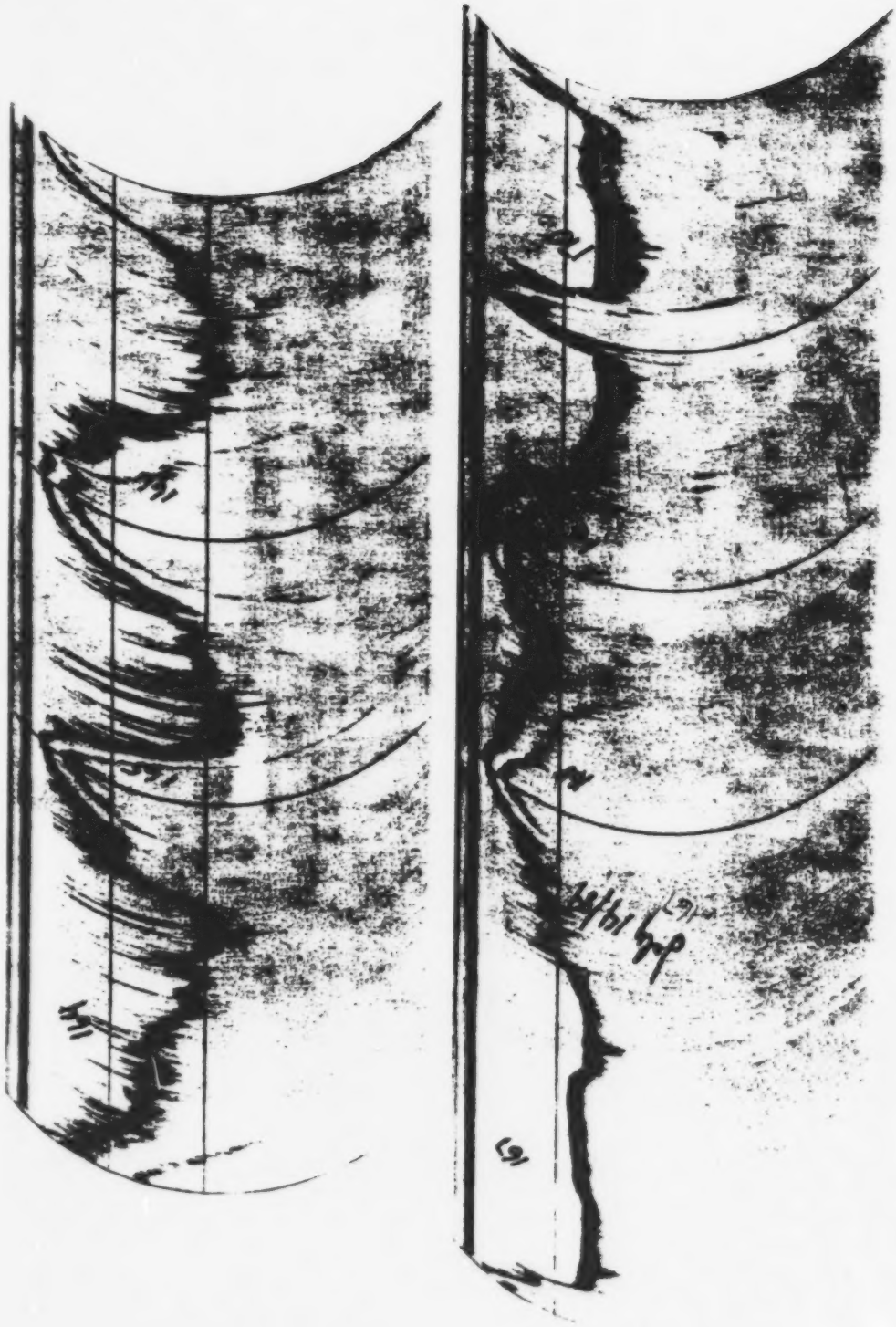

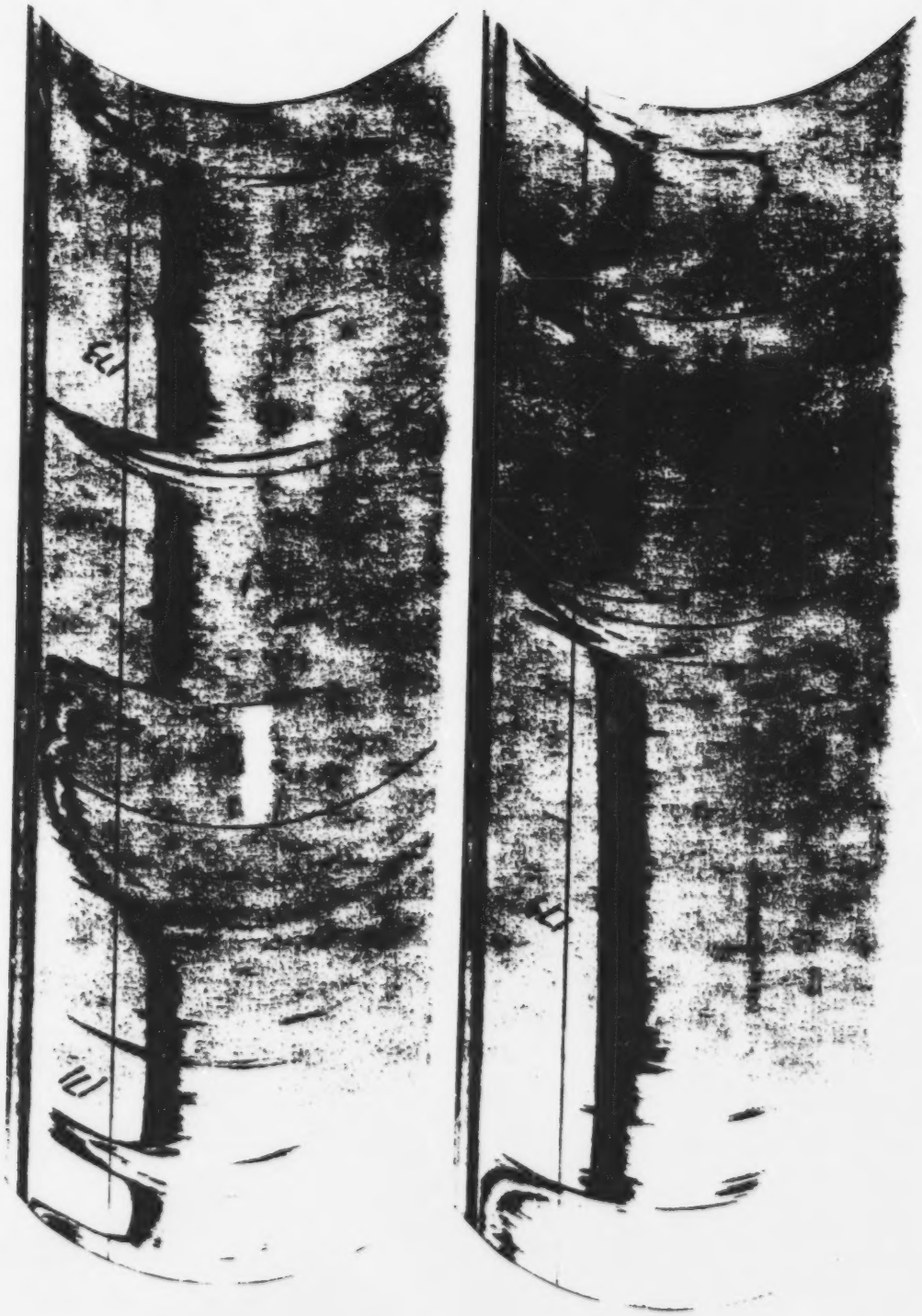

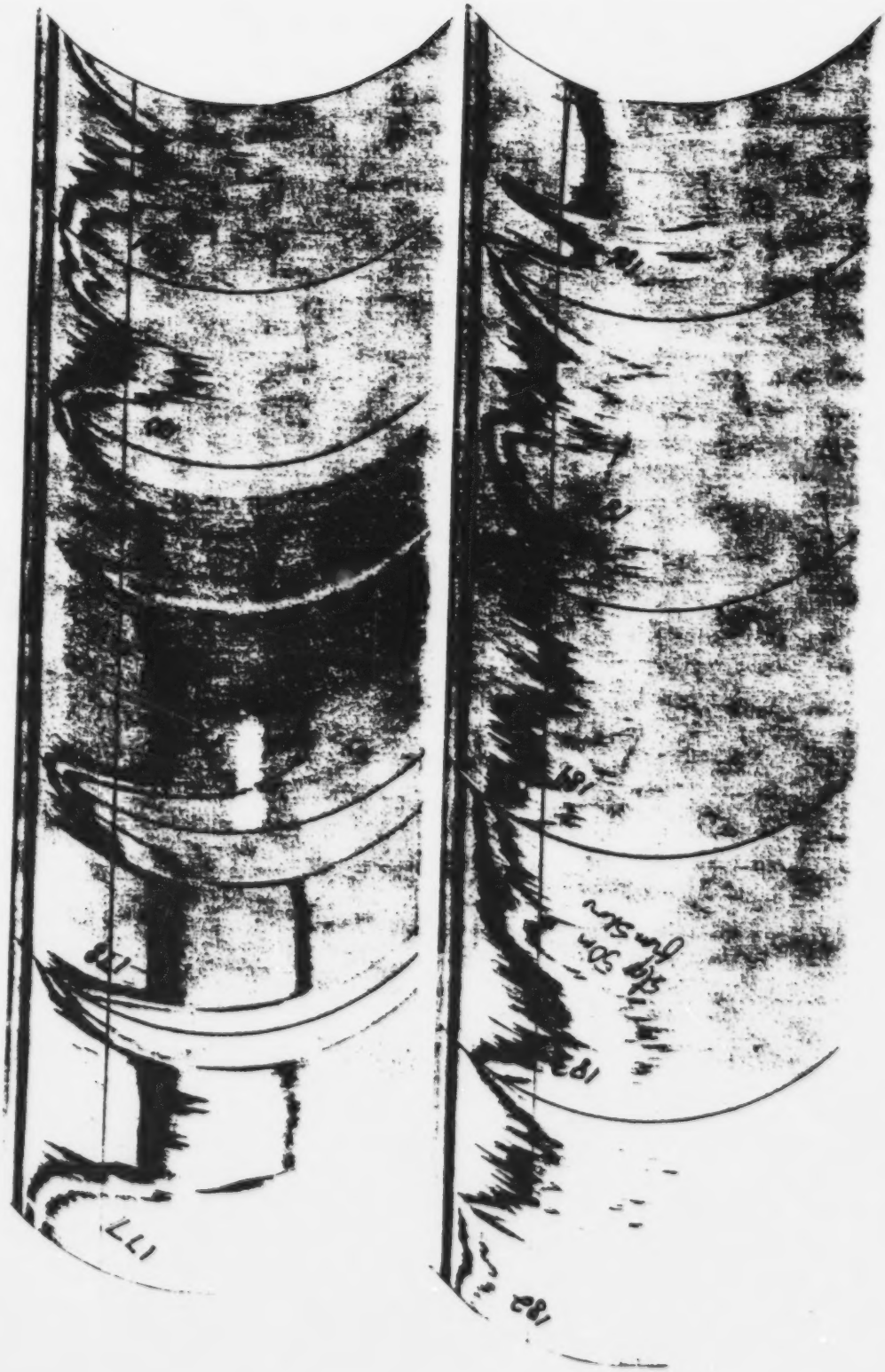

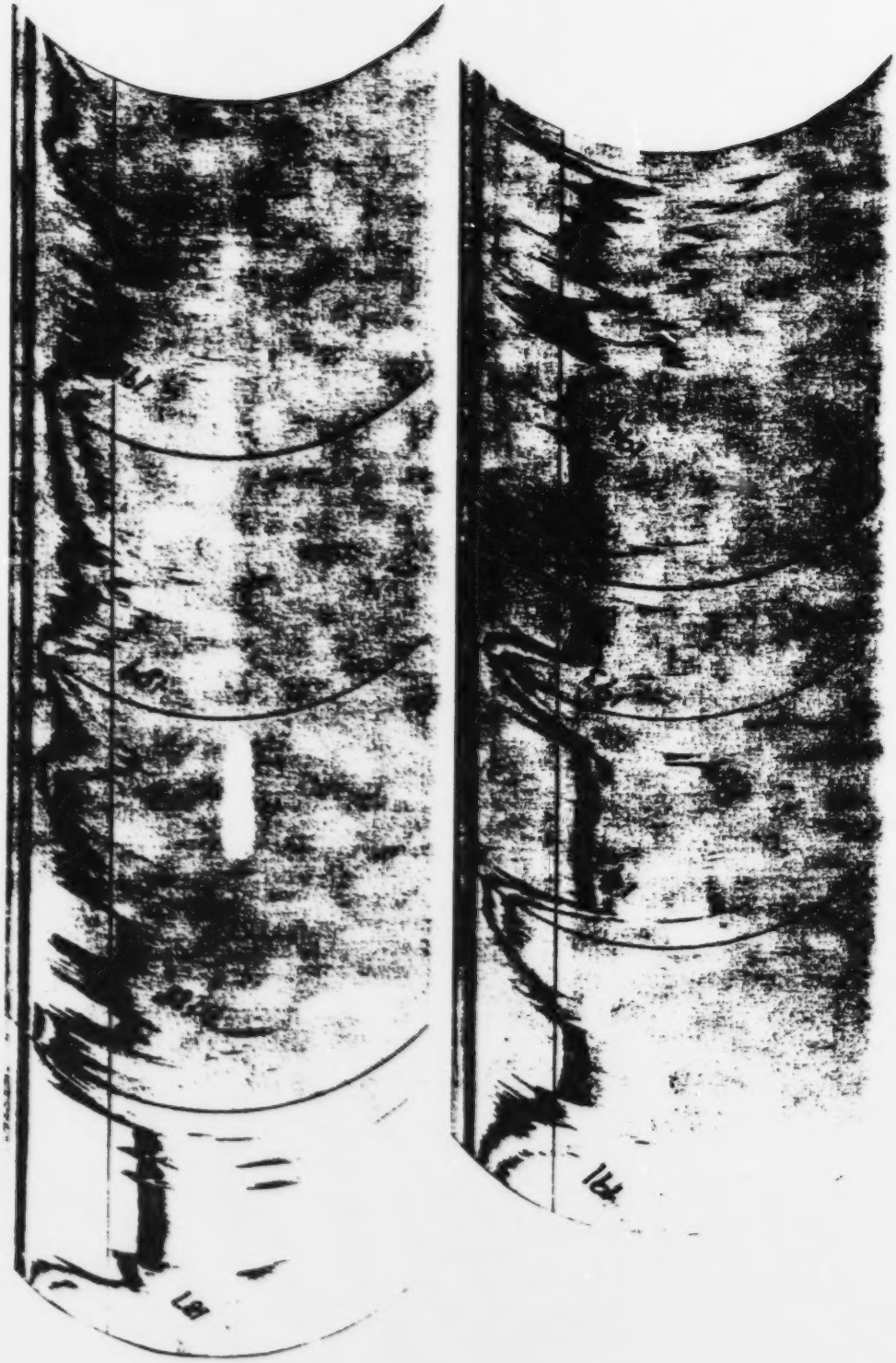

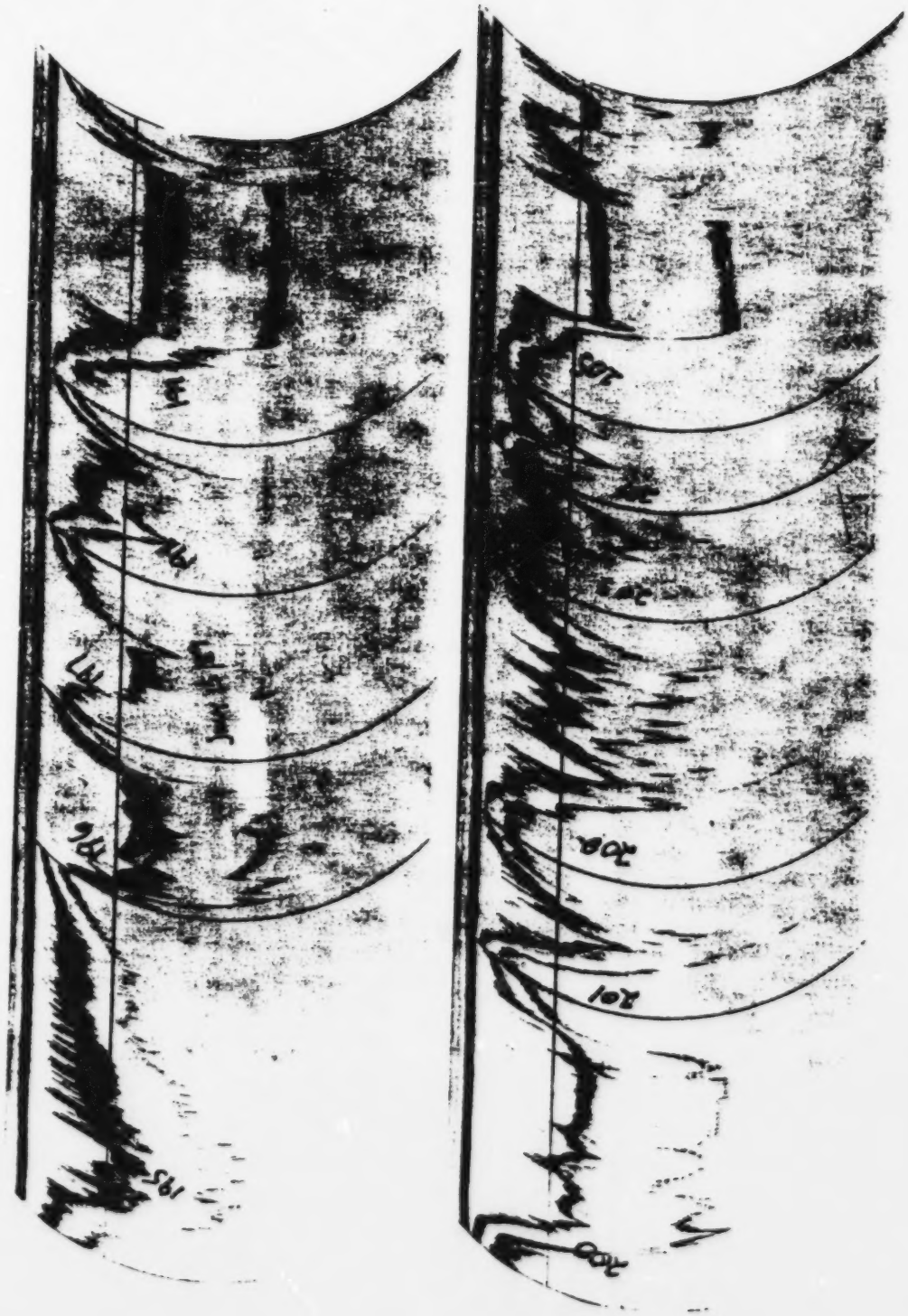
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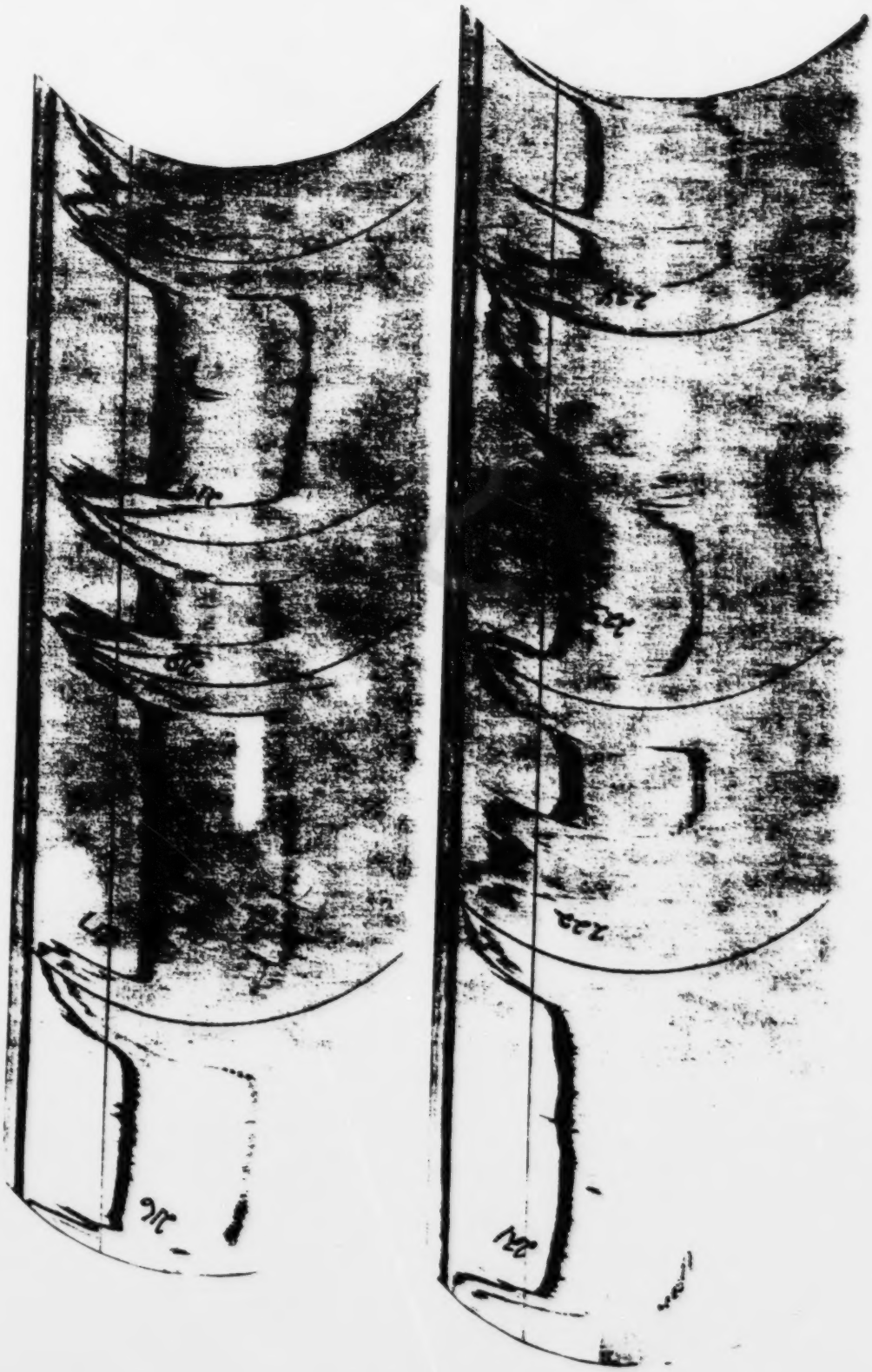

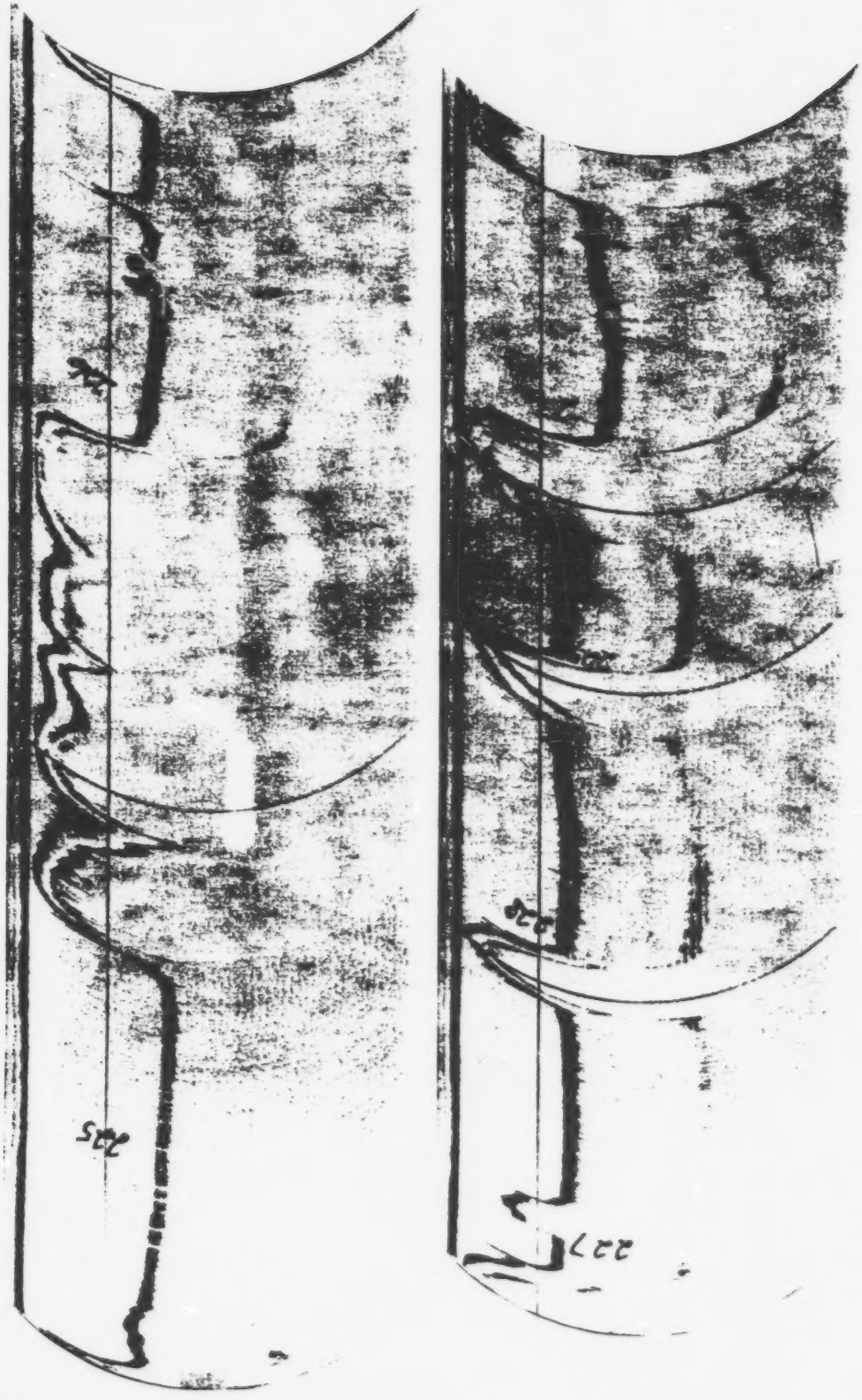

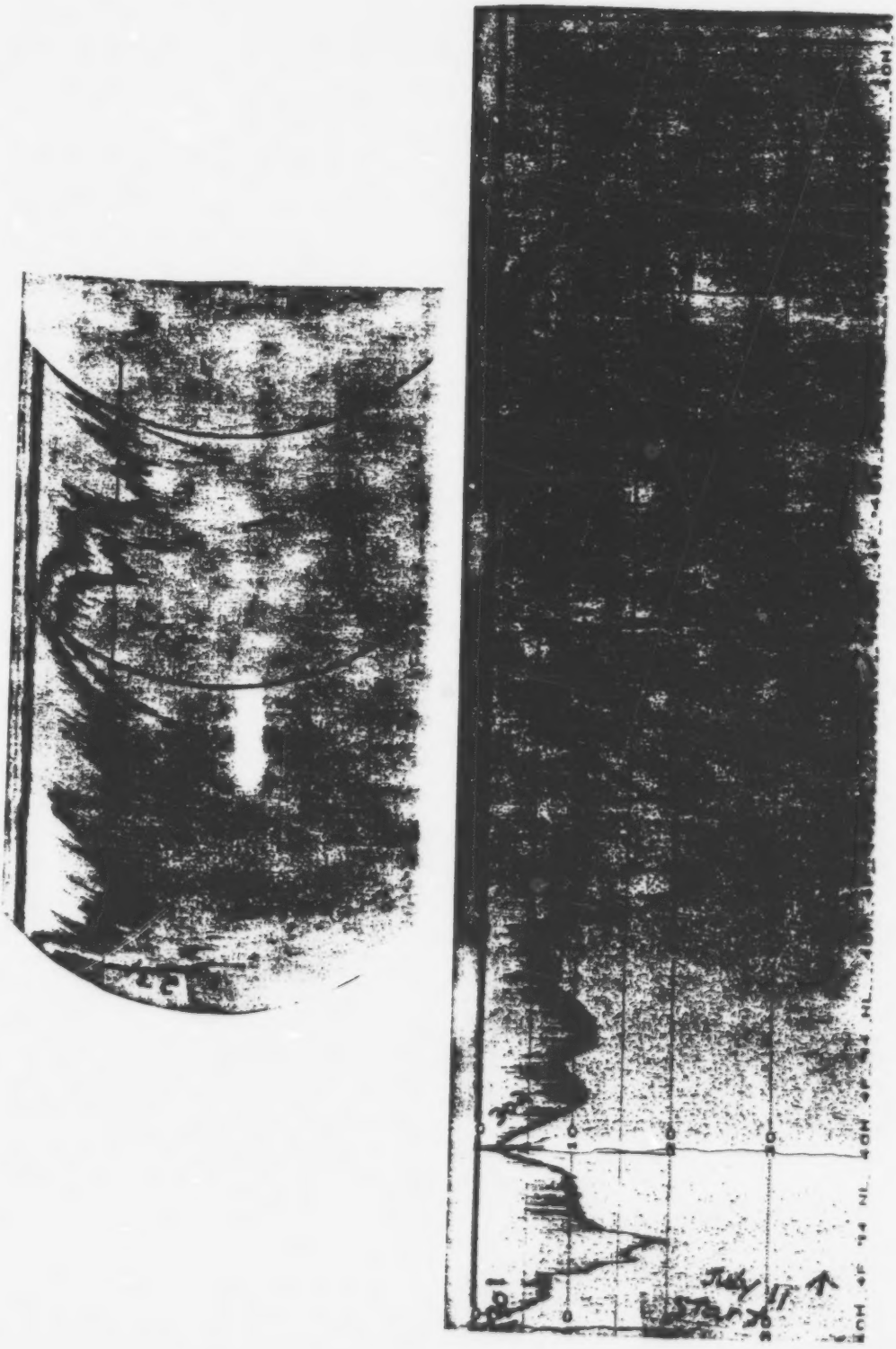

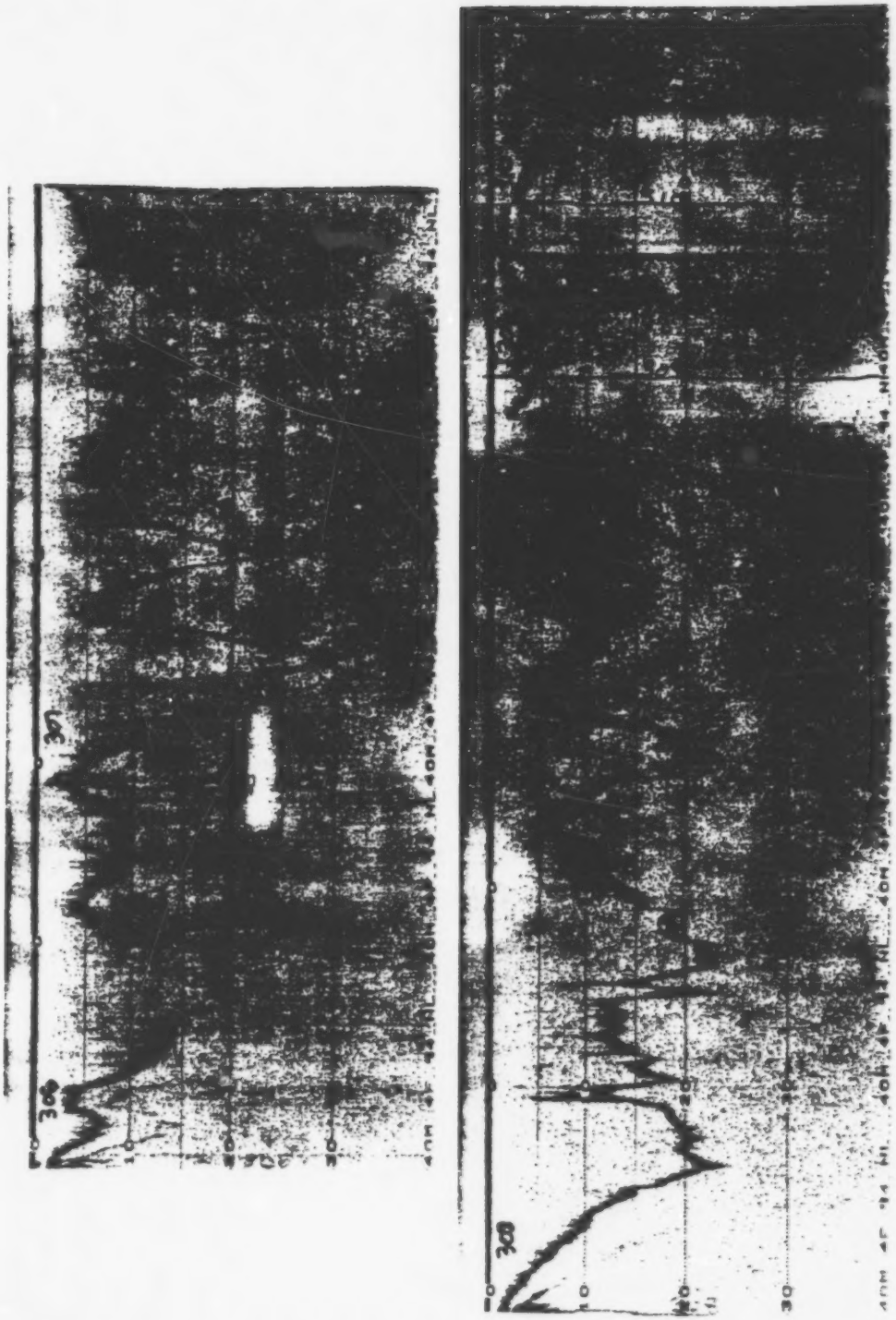

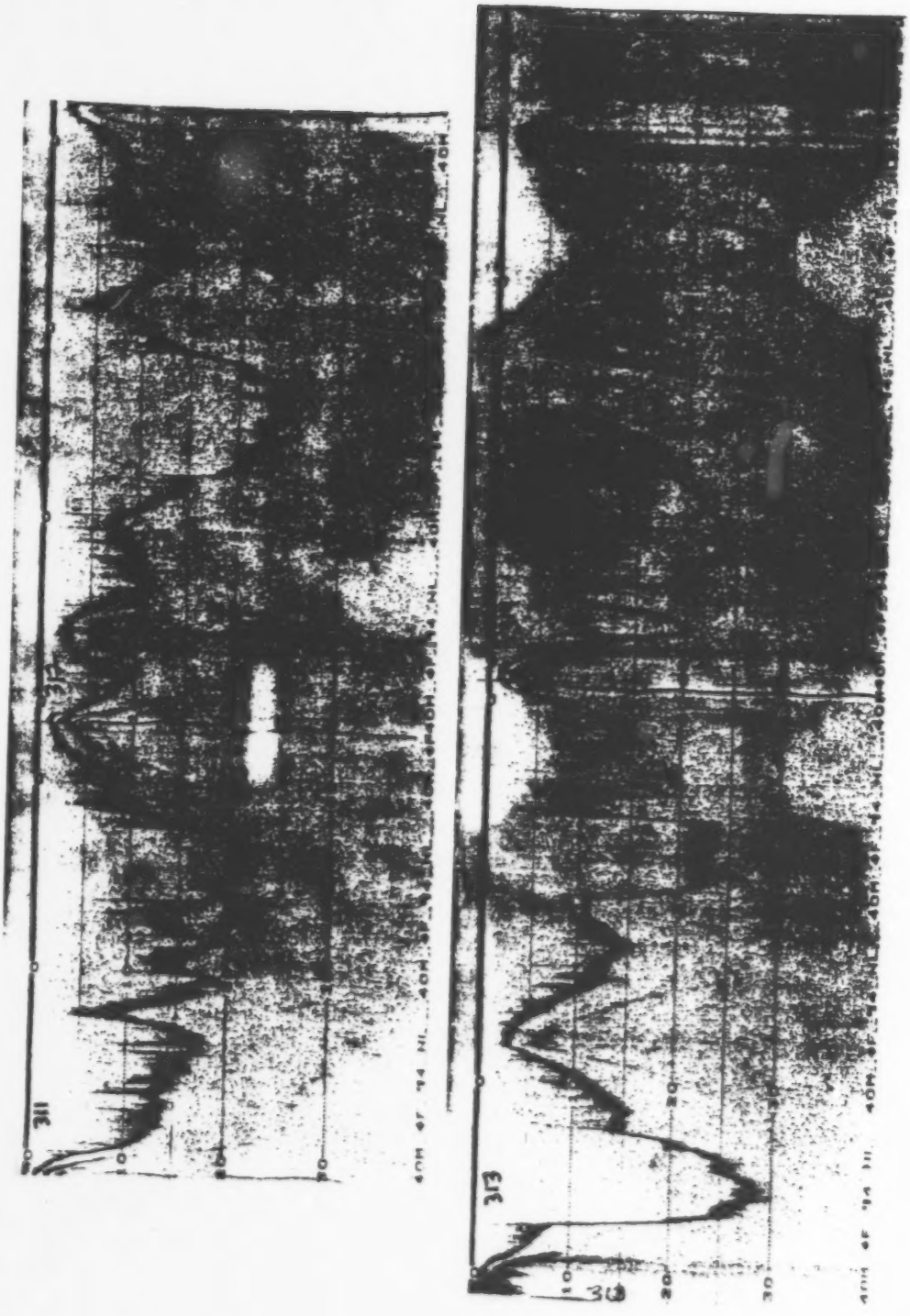

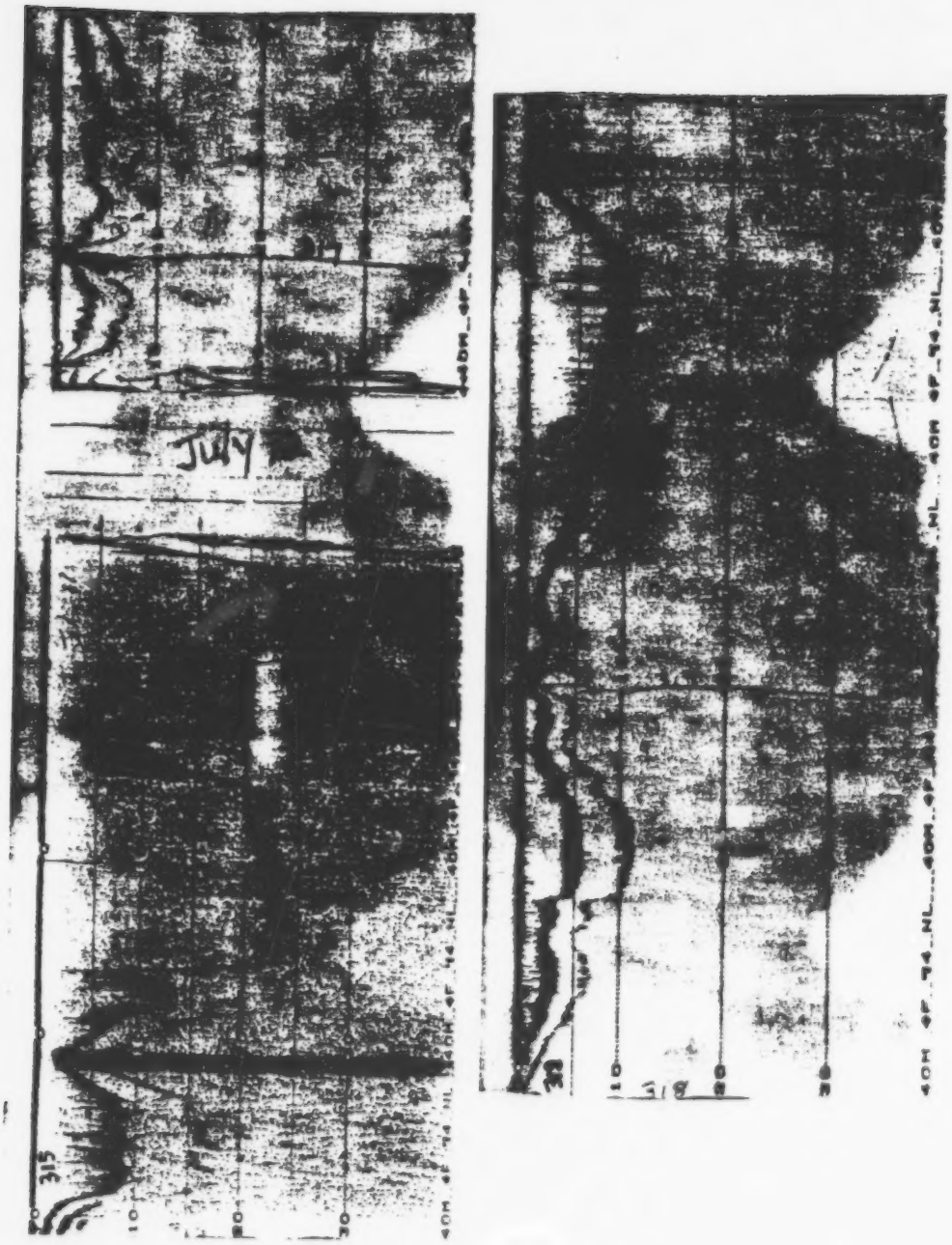
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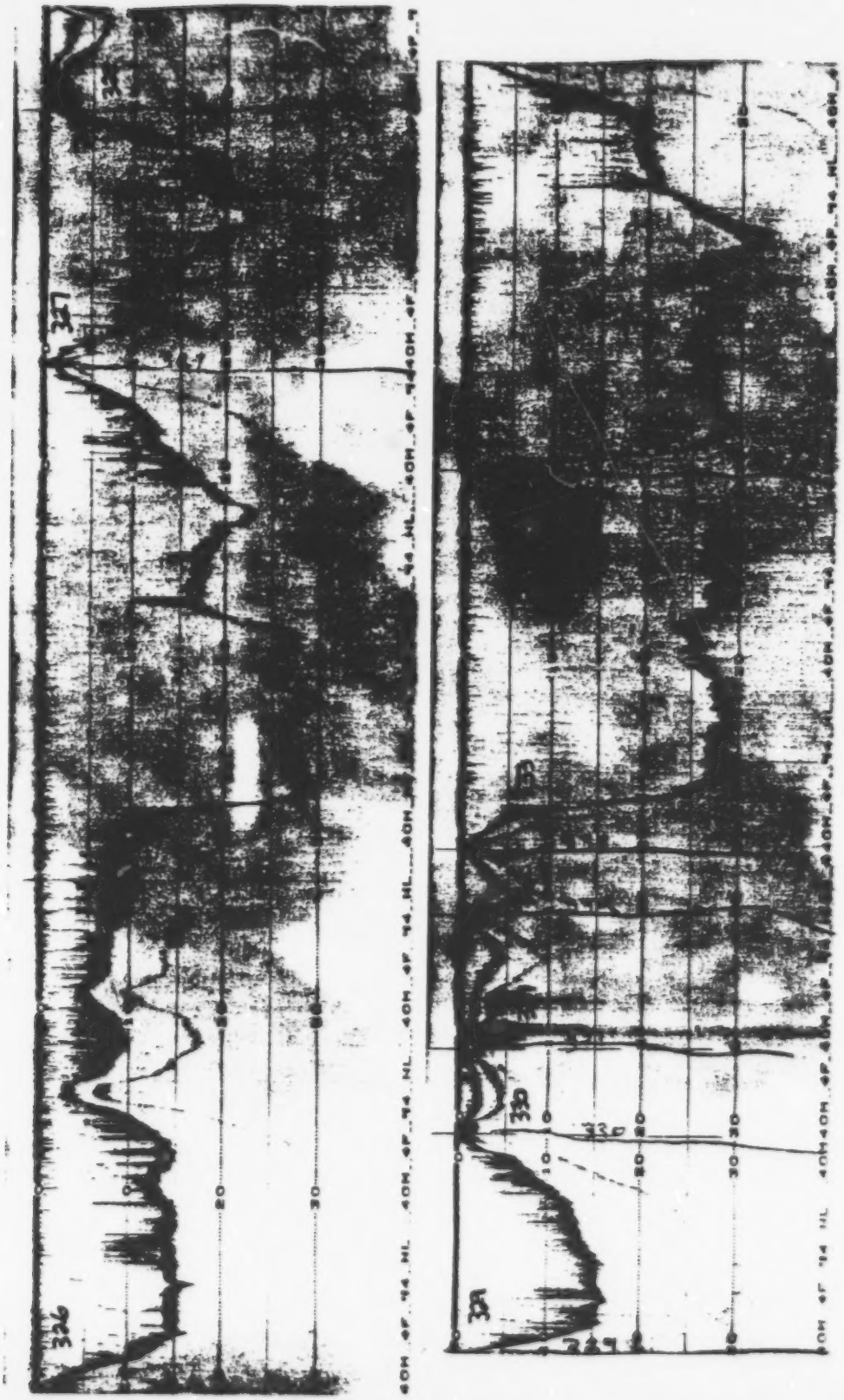

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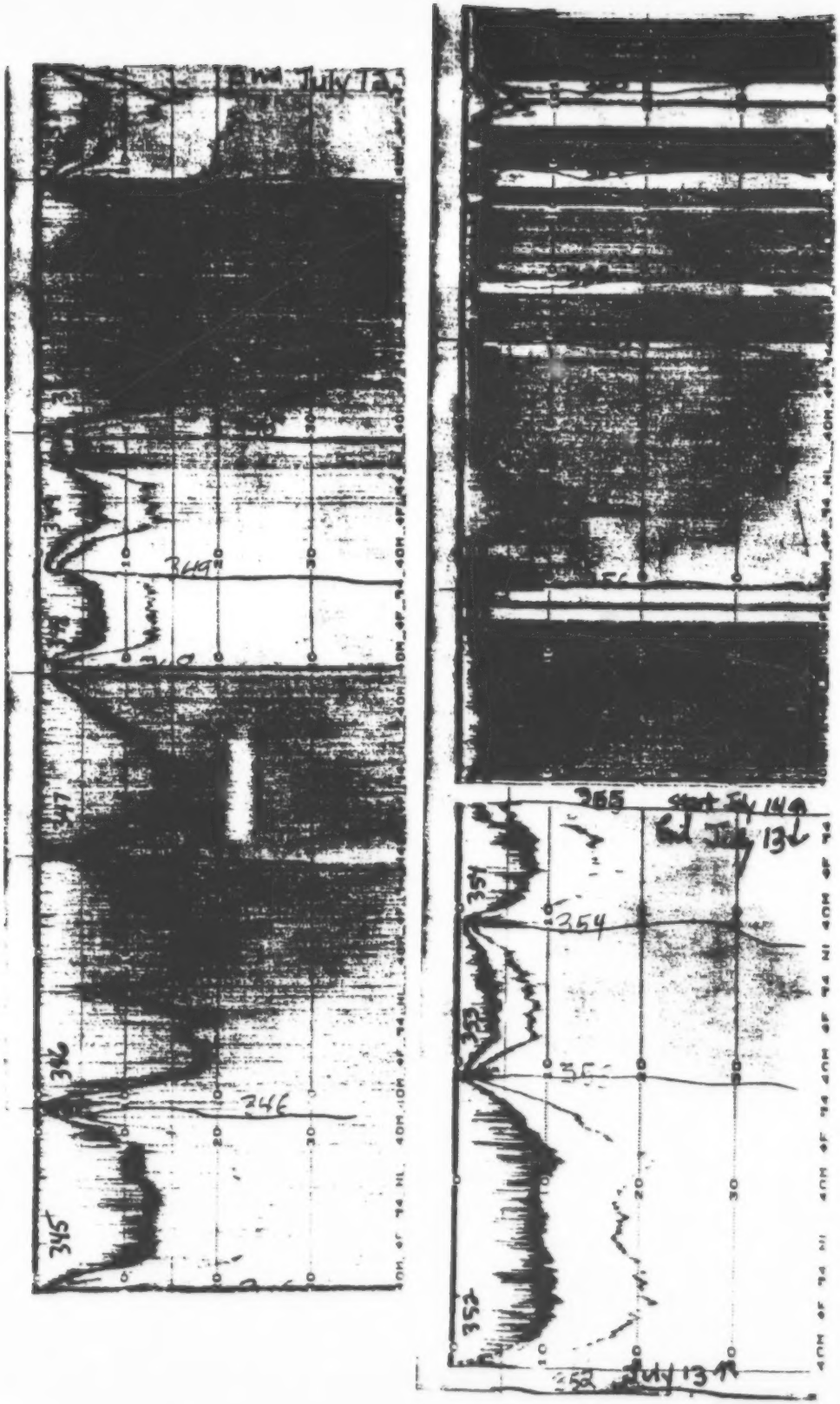
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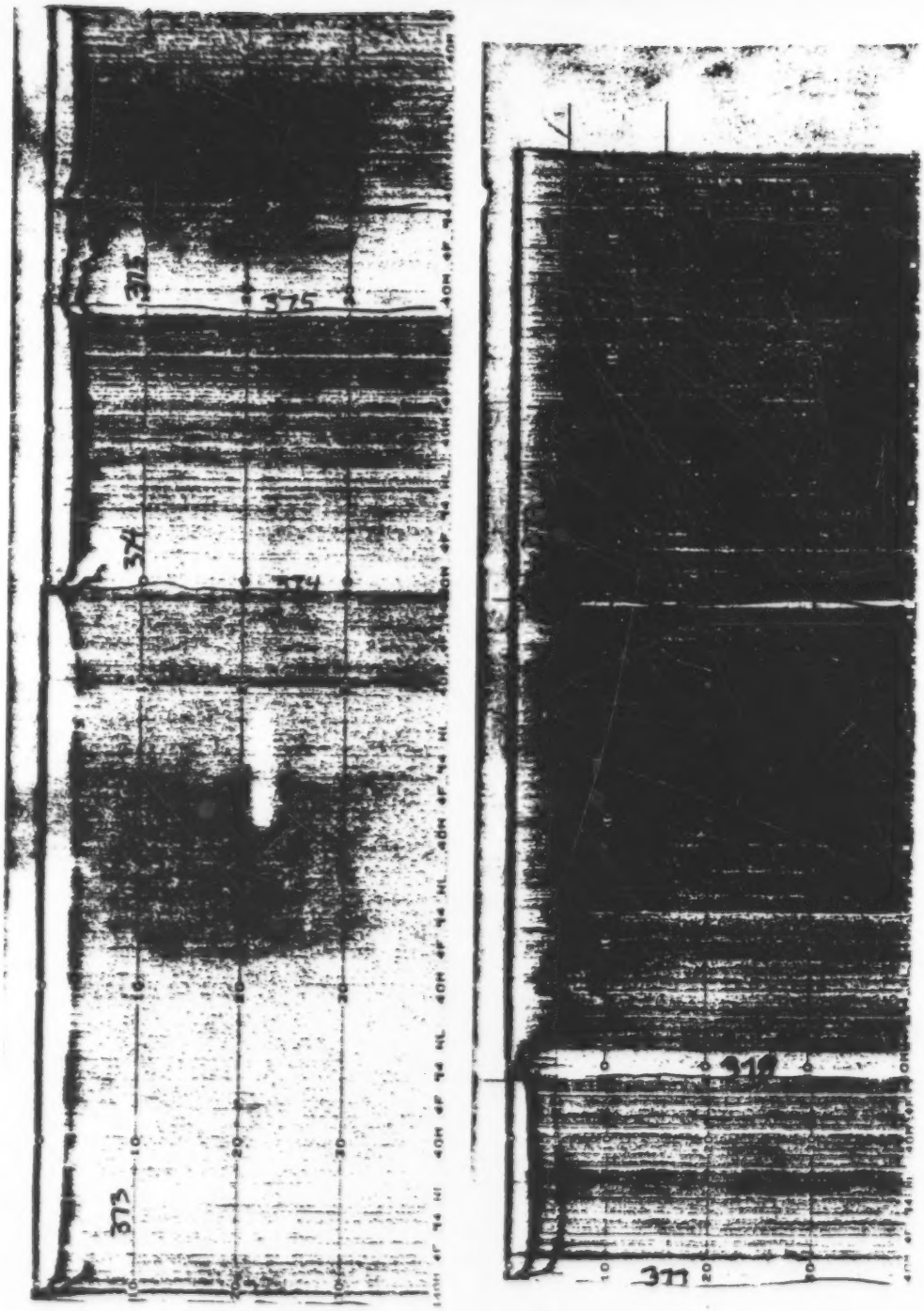
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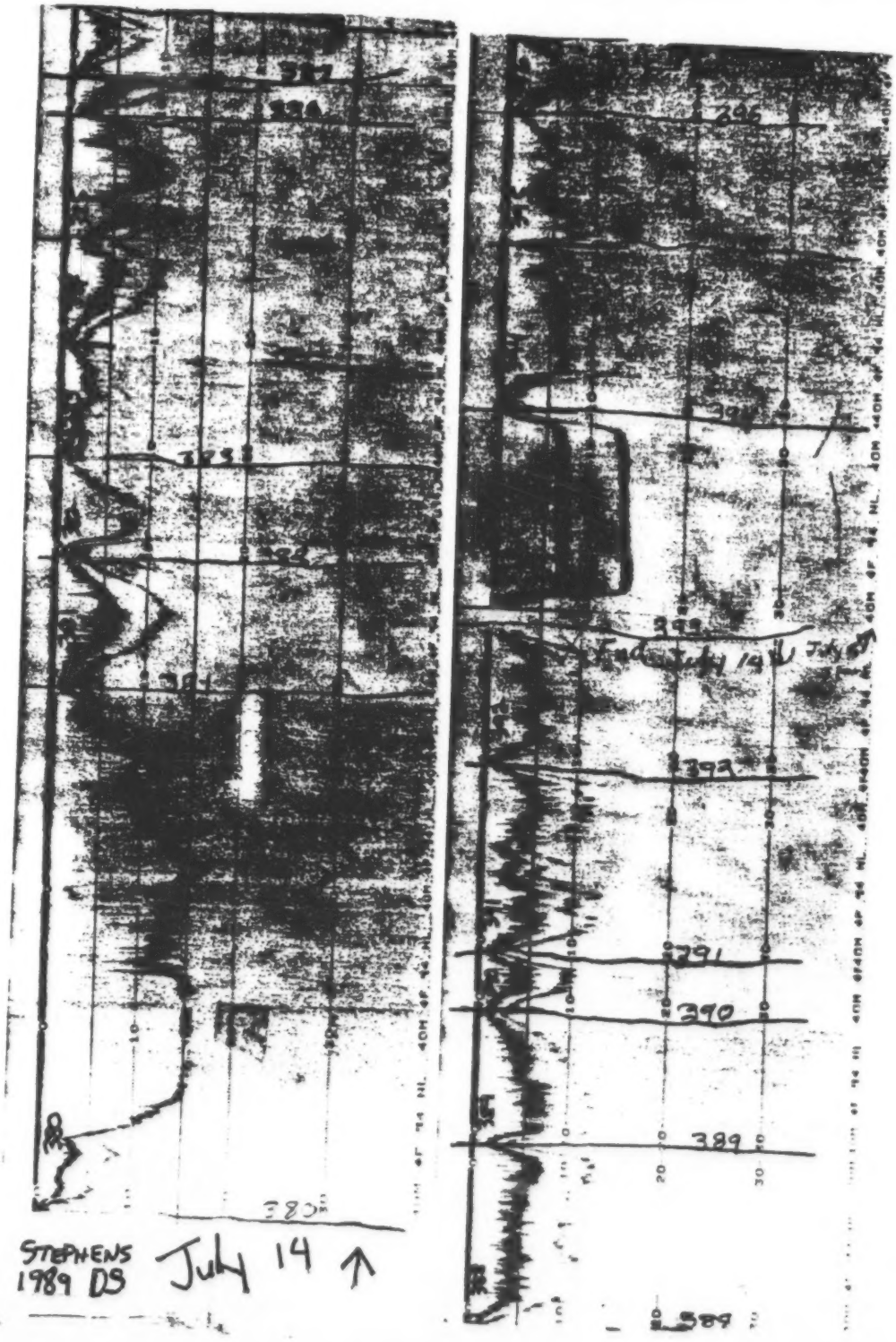
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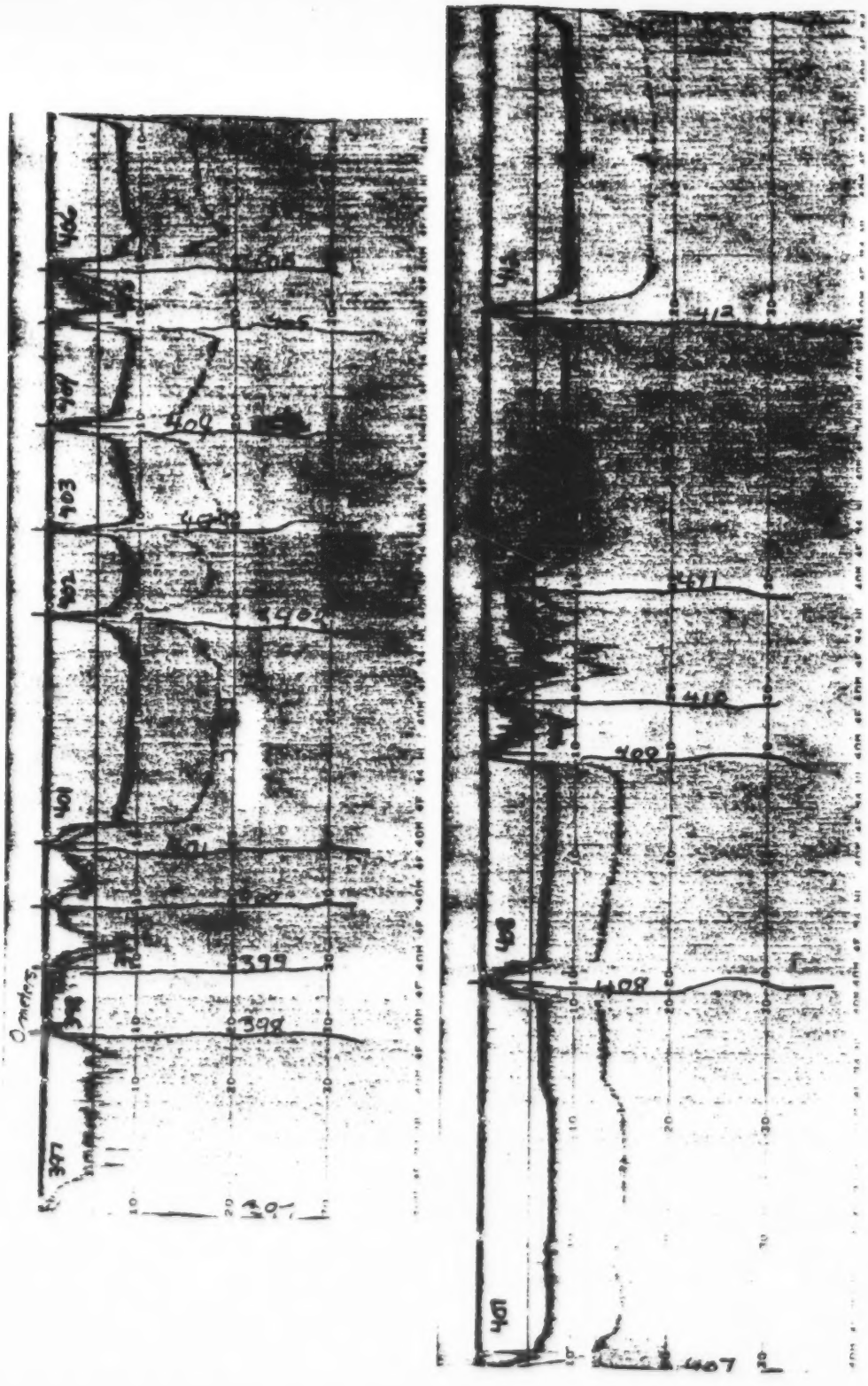
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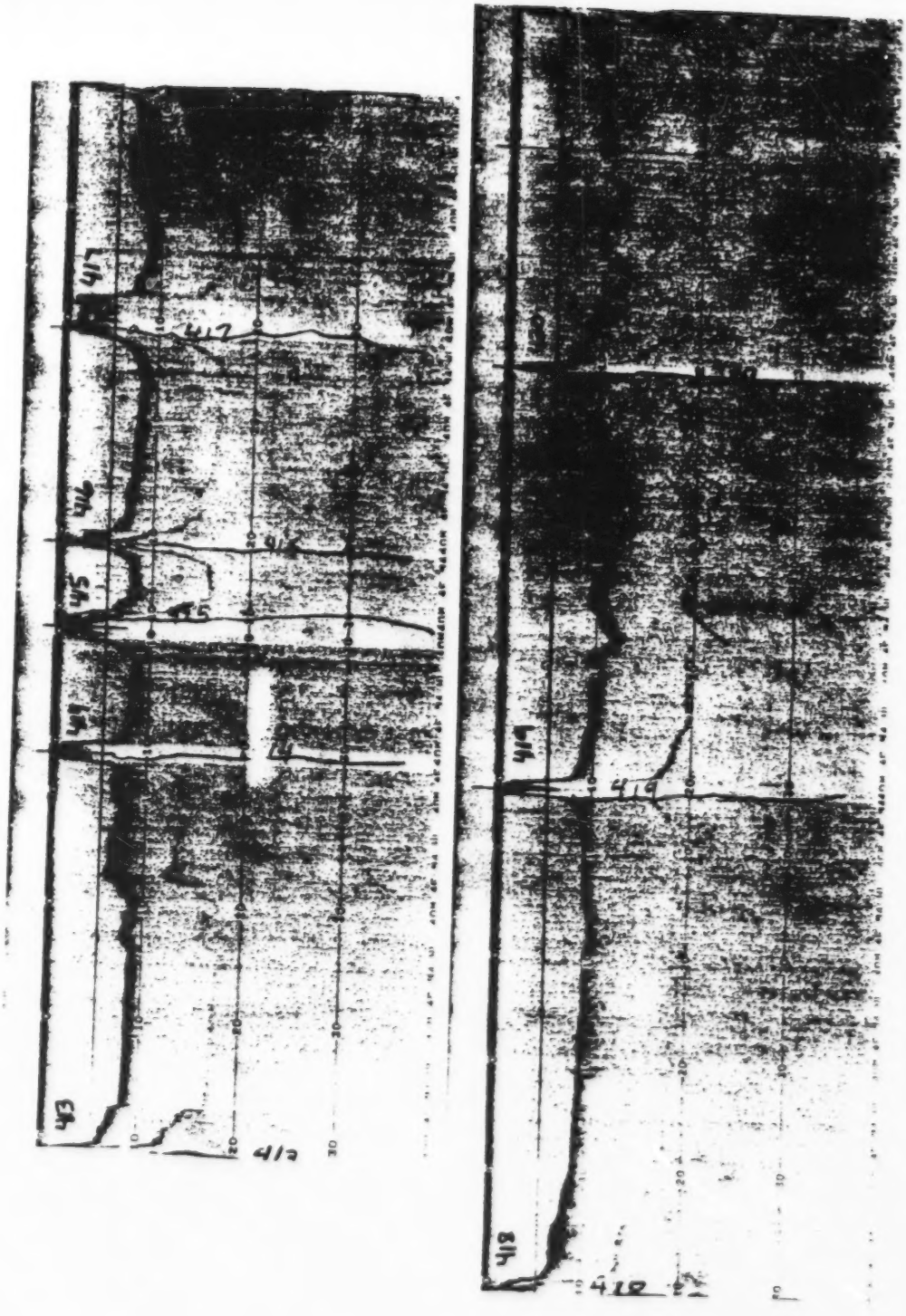
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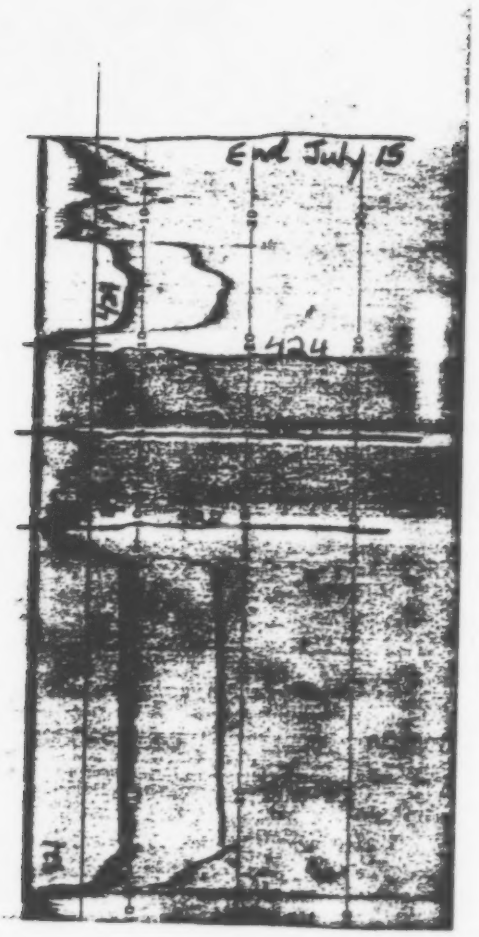
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Appendix 3. List of Manitoba Department of Natural Resources Fisheries Branch reports written to date on data collected from the Churchill-Nelson River Diversion under the Northern Flood Agreement Claim numbers 12 and 18. Documents are listed in chronological order of publication.

Year	Title
1984	Patalas, J.W. 1984. Fish population data from Sipiwesk, Split and Stephens lakes, 1983. Man. Dept. Nat. Res. Fish. Br. MS Report No. 84-24, 66pp.
	_____1984. Fish population data from Notigi, Wapisu, Threepoint and Footprint lakes, 1983. Man. Dept. Nat. Res. Fish. Br. MS Report No. 84-25, 70pp.
1986	Derksen, A.J. 1986. Ecological Monitoring - Fisheries 1985 Progress Report. Man. Dept. Nat. Res. Fish. Br. April 9, 1986. 43.pp.
	Kirton, J.A.W. 1986. Fish population data from Rat, Karsakuwigamak, and West and Central Mynarski lakes, 1984. Man. Dept. Nat. Res. Fish. Br. MS Report No. 86-03, 48pp.
	_____1986. Fish population data from Split and Stephens lakes, 1984. Man. Dept. Nat. Res. Fish. Br. MS Report No. 86-04, 61pp.
	Green, D.J. 1986. Summary of Fish mercury data collected from lakes on the Rat-Burntwood and Nelson River systems, 1983-1985. Man. Dept. Nat. Res. MS Report No. 86-06, 359 pp.
	Mohr, L.C. and J.A.W. Kirton. 1986. Fish population data from Sipiwesk and Cross lakes, 1985. Man. Dept. Nat. Res. Fish. Br. MS Report No. 86-28, 83pp.
1987	Sopuck, R. D. 1987. A study of lake sturgeon (Acipenser fulvescens) in the Sipiwesk Lake area of the Nelson River, Manitoba, 1976-1978. Man. Dept. Nat. Res., Fish. Br. MS Report No. 87-2, 59pp.
	Hagenson, I. 1987. Fish population data from Rat and Split lakes, 1985. Man. Dept. Nat. Res. Fish. Br. MS Report No. 87-04, 59pp.
	Kirton, J.A.W. 1987. Fish population data from Macheewin, Osik, Footprint and Threepoint lakes, 1984. Man. Dept. Nat. Res. Fish. Br. MS Report No. 87-06, 78pp.

Appendix 3, continued.

Year	Title
1987	Green, D.J. 1987. Summary of fish population data from Rat and Threepoint lakes, 1986. Man. Dept. Nat. Res. Fish. Br. MS. Report No. 87-07, 47pp.
	Kirton, J.A.W. and L.C. Mohr. 1987. Fish population data from Wuskwatim and Apussigamasi lakes, 1984. Man. Dept. Nat. Res. Fish. Br. MS Report No. 87-08, 44pp.
	Sopuck, R.D. 1987. An analysis of changes in the Pipestone Lake fish community from 1980 to 1986. Man. Dept. Nat. Res., Fish. Br. MS Report No. 87-11, 59pp & Appendices.
	Livingston, L. 1987. A checklist of phytoplankton genera for Nelson River and Rat-Burntwood lakes, 1980, 1981 and 1986. Man. Dept. Nat. Res. Fish. Br. MS Report No. 87-14, 20pp.
	Hagenson, I. 1987. Fish population data from Split and Stephens lakes, 1986. Man. Dept. Nat. Res. Fish. Br. MS Report No. 87-26, 59pp.
	Green, D.J. 1987. Summary of fish population data collected from eight lakes on the Rat-Burntwood River System, 1985. Man. Dept. Nat. Res. Fish. Br. MS Report No. 87-27, 130pp.
	Mohr, L. 1987. Fish population data from Sipiwesk and Cross lakes, 1986. Man. Dept. Nat. Res. Fish. Br. MS Report No. 87-28, 87pp.
	Anonymous. 1987. A manual for ecological monitoring - data collection procedures. Man. Dept. Nat. Res. Fish. Br. June, 1987.
	Mohr, L. and Livingston, L. 1987. Ecological monitoring zooplankton analysis methodology for 1986/87. Man. Dept. Nat. Res. Fish. Br. June, 1987.
	Derksen, A.J. and D.J. Green. Total mercury concentrations in large fishes from lakes on the Churchill River Diversion and Nelson River. Canada-Manitoba Agreement on the Study and Monitoring of Mercury in Churchill River Diversion. Tech. Appendices to Summary Report Volume 4, paper no. 17.

Appendix 3, continued.

Year	Title
1988	Derksen, A.J. et.al. 1988. Ecological Monitoring - Fisheries 1986 Progress Report. Man. Dept. Nat. Res., Fish. Br. March, 1988.
	Livingston, L. 1988. Summary of phytoplankton data for the Nelson River and Rat-Burntwood lakes, 1987. Man. Dept. Nat. Res. Fish. Br. MS Report No. 88-04, 164pp.
	Green, D.J. 1988. Summary of fish population data from Rat and Threepoint lakes, 1987. Man. Dept. Nat. Res. Fish. Br. MS. Report No. 88-11, 55pp.
	_____. 1988. Summary of fish population data from Sipiwesk and Cross lakes, 1987. Man. Dept. Nat. Res. Fish. Br. MS Report No. 88-12, 90pp.
	Patalas, J.W. 1988. The effects of commercial fishing on lake sturgeon (Acipenser fulvescens) populations in the Sipiwesk Lake area of the Nelson River, Manitoba, 1987-1988. Man. Dept. Nat. Res. Fish. Br. MS Report No. 88-14, 38pp.
	Hagenson, I. 1988. Fish population data from Split and Stephens lakes, 1987. Man. Dept. Nat. Res. Fish. Br. MS Report No. 88-15, 66pp.
1989	Green, D.J. 1989. Summary of fish population data from Sipiwesk and Cross lakes, 1988. Man. Dept. Nat. Res. Fish. Br. MS. Report No. 89-11, 91pp.
	Livingston, L.R. 1989. Summary of phytoplankton data for the Nelson River and Rat-Burntwood lakes, 1988. Man. Dept. Nat. Res. Fish. Br. MS Report No. 89-07, 81pp.
	Green, D. J. 1989. Summary of fish population data from Sipiwesk and Cross lakes, 1988. Man. Dept. Nat. Res. Fish. Br. MS Report No. 89-11, 91pp.
	Green, D.J. 1989. Summary of fish population data from Rat and Threepoint lakes, 1988. Man. Dept. Nat. Res. Fish. Br. MS Report No. 89-13, 69pp.

Appendix 3, continued.

Year	Title
1989	Cherepak, B. C. 1989. The post-flood morphometry and bathymetry of Rat and Threepoint lakes, 1988. Man. Dept. Nat. Res. Fish. Br. MS Report No. 89-14.
	Ramsey, D. J. et al. 1989. Evolution of limnological conditions in lakes of the Nelson and Rat-Burntwood river systems after Churchill River diversion and Lake Winnipeg regulation: I. An Overview. Man. Dept. Nat. Res. Fish. Br. MS Report No. 89-15.
	Hagenson, I. 1989. Fish population data from Split and Stephens lakes, 1988. Man. Dept. Nat. Res. Fish. Br. MS Report No. 89-16.
1990	Green, D. J. 1990. Summary of fish population data from Rat and Threepoint lakes, 1989. Man. Dept. Nat. Res. Fish. Br. MS. Report No. 90-05.
	Green, D. J. 1990. Summary of fish population data from Sipiwesk and Cross lakes, 1989. Man. Dept. Nat. Res., Fish. Br. MS. Report No. 90-06.
	Hagenson, I. 1990. Fish popualtion data from Split and Stephens lakes, 1989. Man. Dept. Nat. Res., Fish. Br. MS. Report No. 90-07.

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